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# Long-Term Effects of Land Application of Domestic Wastewater: Vineland, New Jersey, Rapid Infiltration Site

**Benham-Blair and Affiliates, Inc, Oklahoma City**

**Prepared for**

**Robert S Kerr Environmental Research Lab, Ada, OK**

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This report presents the findings of a study on the long-term effects of applying treated domestic wastewater to an infiltration site at Vineland, New Jersey. Primary treated domestic wastewater has been applied to three separate infiltration basins for approximately 50, 29, and 3 years, respectively, using a high rate, rapid infiltration method. The effluent applied to Basin I serves the Borough of Vineland, while the effluent applied to Basins II and III serves the Landis Sewerage Authority. Water and soil samples from this site were compared with similar samples from an upstream control area not receiving wastewater application.

Sample analyses included metals, nutrients, organics, bacteria, and viruses. There was considerable variation in basin performance; however, the performance of the separate basins was generally quite consistent with loading rates, service life, and hydrogeology.

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# Long-Term Effects of Land Application of Domestic Wastewater

## Vineland, New Jersey, Rapid Infiltration Site

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EPA-600/2-79-072
March 1979

# LONG-TERM EFFECTS OF LAND APPLICATION OF DOMESTIC WASTEWATER:
## Vineland, New Jersey, Rapid Infiltration Site

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## FOREWORD

The Environmental Protection Agency was established to coordinate the administration of major Federal programs designed to protect the quality of our environment.

An important part of the agency's effort involves the search for information about environmental problems, management techniques, and new technologies through which optimum use of the nation's land and water resources can be assured and the threat pollution poses to the welfare of the American people can be minimized.

EPA's Office of Research and Development conducts this search through a nationwide network of research facilities. As one of these facilities, the Robert S. Kerr Environmental Research Laboratory is responsible for the management of programs including the development and demonstration of soil and other natural systems for the treatment and management of municipal wastewaters.

Although land application of municipal wastewaters has been practiced for years, there has been a growing and widespread interest in this practice in recent years. The use of land application received major impetus with the passage of the 1972 amendments to the Federal Water Pollution Control Act. The 1977 amendments to the Act gave further encouragement to the use of land application and provided certain incentives for the funding of these systems through the construction grants program. With the widespread implementation of land application systems, there is an urgent need for answers to several major questions. One of these questions regards the long-term effects of land application on the soil, crops, groundwater, and other environmental components. This report is one in a series of ten which documents the effects of long-term wastewater application at selected irrigation and rapid infiltration study sites. These case studies should provide new insight into the long-term effects of land application of municipal wastewaters.

This report contributes to the knowledge which is essential for the EPA to meet the requirements of environmental laws and enforce pollution control standards which are reasonable, cost effective, and provide adequate protection for the American public.

William C. Galegar

William C. Galegar
Director
Robert S. Kerr Environmental Research Laboratory

# ABSTRACT

This report presents the findings of a study on the long-term effects of applying treated domestic wastewater to an infiltration site at Vineland, New Jersey. Primary treated domestic wastewater has been applied to three separate infiltration basins for approximately 50, 29, and 3 years, respectively, using a high rate, rapid infiltration method. The effluent applied to Basin I serves the Borough of Vineland, while the effluent applied to Basins II and III serves the Landis Sewerage Authority. Water and soil samples from this site were compared with similar samples from an upstream control area not receiving wastewater application.

Data on a number of parameters were evaluated against information about the natural features of the Vineland physiographic region. Methods used in the field and laboratory analyses are described in sufficient detail to provide a basis for comparison of these results to other studies.

An essential aspect of evaluating water analyses is understanding the hydrogeology of the area. Knowledge of depth and movement of groundwater and location and thickness of aquifers was essential in interpreting data from wells strategically placed on both test and control sites.

Mean concentrations of 18 of the 48 parameters analyzed statistically were found to be significantly greater in the effluent applied to Basin I than in the control groundwater. Sixteen of the eighteen parameters were found to be significantly greater in the test site groundwater below Basin I than in the control groundwater.

Similarly, differences in 20 mean concentrations out of 48 parameters analyzed were found to be significantly greater in the Landis effluent applied to Basins II and III than in the control groundwater. For test groundwater below Basin II and Basin III, mean concentrations for 17 and 13 parameters, respectively, were found to be significantly greater than concentrations in the control groundwater.

Surface water samples taken downgradient from the infiltration basins in the Parvin Branch tributary of the Maurice River indicated that migration of constituents from the groundwater to the surface water was occurring. Similar surface water samples from the Maurice River did not reveal this migration and likely reflected the dilution effect of the greater flow in the Maurice River than in the Parvin Branch.

Analyses of soil samples taken at three different depths from beneath the infiltration basins and the upgradient control sites indicated significant accumulations of nitrogen, phosphorus, and zinc to be occurring below the infiltration basins down to the deepest depth sampled.

This report was submitted in partial fulfillment of Contract No. 68-03-2363 by Benham-Blair & Affiliates, Inc., as the principal contractor; Engineering Enterprises, Inc. as subcontractor; with three cooperating companies: Sheaffer and Roland, Inc.; D. E. Matschke Company; and W. J. Bauer Consulting Engineers, Inc.; under the sponsorship of the U.S. Environmental Protection Agency. This report covers the period from January, 1976, to November, 1977; work was completed as of September, 1978.

# CONTENTS

Foreword . . . iii
Abstract . . . iv
Figures . . . viii
Tables . . . x
List of Abbreviations and Symbols . . . xii
Acknowledgments . . . xiv

1. Introduction . . . 1
2. Conclusions . . . 3
3. Site-Selection Process . . . 5
    General Criteria . . . 5
    Mid-Atlantic States Sites . . . 7
4. Description of Site . . . 9
    General . . . 9
    Test Site . . . 9
    Control Site . . . 9
    Groundwater Hydrology and Geology . . . 9
    Surface Water . . . 15
    Soils . . . 18
    Climate . . . 19
    Land Use . . . 22
5. Plant Operation and Costs . . . 23
    Borough of Vineland Treatment Plant . . . 23
    Landis Sewerage Authority Treatment Plant . . . 23
    Wastewater Characteristics . . . 24
    Infiltration of Wastewater . . . 24
    Operating Costs . . . 25
6. Research Methods . . . 26
    Well Construction and Locations . . . 26
    Chemical and Biological Analyses . . . 34
    Data Evaluation Plan . . . 46
7. Results and Discussion . . . 51
    Water . . . 51
    Soils . . . 105
    Projected Useful Life of Site for Wastewater Infiltration . 113

References . . . 116

Appendices

A. Well Logs for Control and Test Sites . . . 119
B. Data Tables for All Water and Soil Samples . . . 135

Glossary . . . 164

**Preceding page blank**

FIGURES

| Number | | Page |
|---|---|---|
| 1 | Rapid infiltration . . . . . . . . . . . . . . . . . . . . . . . . . . . | 2 |
| 2 | Location map . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | 10 |
| 3 | Groundwater level contours, Cumberland Co., New Jersey . . . . . . | 12 |
| 4 | Water elevation contours, August, 1976, and cross section locations . . . . . . . . . . . . . . . . . . . . . . . . . . | 13 |
| 5 | Water level contours, December, 1976 . . . . . . . . . . . . . . . | 14 |
| 6 | Vineland, N.J. stream flow measuring and sampling stations . . . . | 16 |
| 7 | Typical aboveground construction . . . . . . . . . . . . . . . . . . | 27 |
| 8 | Test holes and sample wells, Vineland, N.J. . . . . . . . . . . . . | 31 |
| 9 | Well location at sewage disposal plant . . . . . . . . . . . . . . . | 32 |
| 10 | Cross section A-A' Vineland, N.J. . . . . . . . . . . . . . . . . . | 47 |
| 11 | Cross section B-B' Vineland, N.J. . . . . . . . . . . . . . . . . . | 48 |
| 12 | Cross section C-C' Vineland, N.J. . . . . . . . . . . . . . . . . . | 49 |
| 13 | Sample well location map Vineland, N.J. . . . . . . . . . . . . . . | 58 |
| 14 | Groundwater constituents - ammonium nitrogen . . . . . . . . . . . | 69 |
| 15 | Groundwater constituents - soluble organic nitrogen . . . . . . . | 72 |
| 16 | Groundwater constituents - nitrate nitrogen . . . . . . . . . . . . | 73 |
| 17 | Groundwater constituents - COD . . . . . . . . . . . . . . . . . . . | 75 |
| 18 | Groundwater constituents - chloride . . . . . . . . . . . . . . . . | 77 |
| 19 | Groundwater constituents - dissolved solids . . . . . . . . . . . . | 78 |
| 20 | Groundwater constituents - boron . . . . . . . . . . . . . . . . . . | 79 |

Number Page

21 Groundwater constituents - potassium . . . . . . . . . . . . . . . . 82

22 Groundwater constituents - calcium . . . . . . . . . . . . . . . . . 83

23 Groundwater constituents - soluble phosphorus . . . . . . . . . . 85

24 Groundwater constituents - iron . . . . . . . . . . . . . . . . . . 88

25 Groundwater constituents - zinc . . . . . . . . . . . . . . . . . . 89

26 Groundwater constituents - lindane . . . . . . . . . . . . . . . . . 92

27 Groundwater constituents - total coliform . . . . . . . . . . . . 94

28 Groundwater constituents - fecal coliform . . . . . . . . . . . . 95

29 Groundwater constituents - infectious virus units . . . . . . . . 99

30 Total inorganic and organic nitrogen mean concentrations in control and test site soils . . . . . . . . . . . . . . . . . . . . 108

31 Total and available phosphorus mean concentrations in control and test site soils . . . . . . . . . . . . . . . . . . . . . . . 109

32 Total zinc and copper mean concentrations in control and test site soils . . . . . . . . . . . . . . . . . . . . . . . 110

33 Total potassium and magnesium mean concentrations in control and test site soils . . . . . . . . . . . . . . . . . . . . . . . 111

34 Total iron and manganese mean concentrations in control and test site soils . . . . . . . . . . . . . . . . . . . . . . . 112

## TABLES

Number Page

1 Comparison of Sites Located in Mid-Atlantic States . . . . . . . . 8

2 Summary of Flow Measurements on Maurice River, Parvin and Tarkiln Branches . . . . . . . . . . . . . . . . . . . . . . . . . 17

3 Temperature and Precipitation Data . . . . . . . . . . . . . . . . 20

4 Recent Climatological Data . . . . . . . . . . . . . . . . . . . . 21

5 Wastewater Characteristics . . . . . . . . . . . . . . . . . . . . 24

6 Well Summary Table . . . . . . . . . . . . . . . . . . . . . . . . 28

7 Summary of Field Methods . . . . . . . . . . . . . . . . . . . . . 35

8 Summary of Constituent Concentrations in Vineland and Landis Treatment Plant Effluents and Vineland Municipal Water Supply . . 52

9 Mean Concentrations of Parameters in Control Site Groundwater and the Applied Vineland and Landis Effluents . . . . . . . . . . 55

10 Mean Concentrations of Parameters in Control Site Groundwater and Test Groundwater Below Basin I . . . . . . . . . . 60

11 Mean Concentrations of Parameters in Control Site Groundwater and Test Groundwater Below Basin II . . . . . . . . . . 61

12 Mean Concentrations of Parameters in Control Site Groundwater and Test Groundwater Below Basin III . . . . . . . . . 62

13 Summary of Parameter Mean Concentration Comparisons Between the Test Groundwater of the Three Basins . . . . . . . . . . . . 64

14 Mean Concentrations of Parameters in the Groundwaters Beneath the Landfill and Basin III . . . . . . . . . . . . . . . 65

15 Mean Concentrations of Parameters in the Groundwaters Beneath Basin I, Downgradient and Intermediate Wells . . . . . . . 66

16 Mean Concentrations of Parameters in the Groundwaters Beneath Basin II and Downgradient Wells . . . . . . . . . . . . . 68

Number Page

17 Comparison of Chloride, TDS, and Boron Applied To and Passing Each Infiltration Basin . . . . . . . . . . . . . . . . . . 80

18 Comparison of Potassium, Calcium, Sodium, and Magnesium Applied to and Passing Each Infiltration Basin . . . . . . . . . . . 84

19 Comparison of Soluble Phosphorus and Soluble Orthophosphate Applied To and Passing Each Infiltration Basin . . . . . . . . . . . 86

20 Comparison of Iron, Manganese, and Zinc Applied To and Passing Each Infiltration Basin . . . . . . . . . . . . . . . . . 87

21 Virus Isolation . . . . . . . . . . . . . . . . . . . . . . . . 96

22 Virus Isolation by the Bentonite Method . . . . . . . . . . . . . 100

23 Mean Concentrations of Parameters in Maurice River Water Upstream (Control) and Downstream (Test) of the Treatment Plant . 102

24 Mean Concentrations of Parameters in Parvin Branch Water Upstream (Control) and Downstream (Test) of the Treatment Plant . 103

25 Calculation and Comparison of Incremental Flow Concentrations of Statistically Significant Parameters . . . . . . . . . . . . . 104

26 Mean Concentrations of Parameters in Control and Test Site Soils . 106

27 Phosphorus, Copper and Zinc Balances . . . . . . . . . . . . . . 114

# LIST OF ABBREVIATIONS AND SYMBOLS

## ABBREVIATIONS

acre-ft -- acre-foot
BOD -- biochemical oxygen demand
$BOD_5$ -- 5-day biochemical oxygen demand
cm -- centimeters
cm/hr -- centimeters per hour
COD -- chemical oxygen demand
DO -- dissolved oxygen
exch -- exchangeable
extr -- extractable
fecal coli -- fecal coliform
g -- grams
gal -- gallons
GL -- ground level
gpd -- gallons per day
gpd/ft -- gallons per day per foot
gpm -- gallons per minute
ha -- hectares
hr -- hours
in -- inches
in/hr -- inches per hour
kg -- kilograms
kg/ha -- kilograms per hectare
kg/ha/yr -- kilograms per hectare per year
km -- kilometers
L -- liters
L/s -- liters per second
L/d/m -- liters per day per meter
lb -- pounds
lb/acre -- pounds per acre
lb/acre/hr -- pounds per acre per hour
m -- meters
$m^3$ -- cubic meters
MCL -- maximum contaminant level
mg/g -- milligrams per gram
mg/L -- milligrams per liter
Mgal/d -- million gallons per day
Mgal/d/ft -- million gallons per day per foot
mi -- miles
mL -- milliliters
mm -- millimeters

mo -- month
ng/g -- nanograms per gram
ng/L -- nanograms per liter
nm -- nanometer
sq ft -- square feet
SR -- slow rate irrigation
SS -- suspended solids
SWL -- static water level
TDS -- total dissolved solids
TOC -- top of casing
total coli -- total coliform
yr -- year
µg/g -- micrograms per gram
µg/L -- micrograms per liter
µmhos/cm -- micromhos per centimeter
#/100 mL -- number of coliform per 100 milliliters of sample

SYMBOLS

Al -- aluminum
As -- arsenic
B -- boron
Ca -- calcium
Cd -- cadmium
Cl -- chlorine
Co -- cobalt
Cr -- chromium
Cu -- copper
Fe -- iron
Hg -- mercury
$H_2SO_4$ -- sulfuric acid
K -- potassium
Mg -- magnesium
Mn -- manganese
N -- nitrogen
Na -- sodium
$NH_3$ -- ammonia
$NH_4$ -- ammonium
Ni -- nickel
$NO_2$ -- nitrite
$NO_3$ -- nitrate
P -- phosphorus
Pb -- lead
S -- sulfur
Se -- selenium
$SO_4$ -- sulfate
Zn -- zinc
> -- greater than
< -- less than
µ -- micron

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The large number of participants in this team project precludes mention of all those who have made substantial contributions. Continual interest and encouragement have been provided by Richard E. Thomas, Project Officer for the EPA. His experience in land treatment projects, technical/scientific expertise in soils, and administrative guidance was essential for the successful completion of the study.

Each of the participating companies had a primary leader or coordinator who took major responsibility for bringing the project to completion. Ernest L. Koerner, Benham-Blair & Affiliates, Inc., was responsible for the overall supervision, chemical analyses, and editing and production of the final report. D. Alan Haws, Engineering Enterprises, Inc., was a senior author and project manager for field construction and sample collection. Donald E. Matschke, D. E. Matschke Company, and Herbert M. Schornick, Engineering Enterprises, Inc., developed the results and discussion and the statistical comparisons. Messrs. William J. Bauer, Keith E. Bennett, William H. Bellis, John S. Fryberger, Harold E. Namminga, W. Russell Street, Dennis G. Lund, Paul K. Law, Lelan K. Martin, R. LeRoy Carpenter, and John R. Sheaffer also made substantial contributions to the project.

In addition, the cooperation and assistance of personnel from the City of Vineland, New Jersey, and the Landis Sewerage Authority were appreciated.

## SECTION 1

## INTRODUCTION

Land application of domestic wastewater is not a new concept, although it has only been in recent years that land treatment has received renewed attention. The multiple advantages of land treatment have been documented by many studies, but almost without exception there has been a lack of data on long-term effects.

Primary effluent from the Vineland and Landis treatment systems is infiltrated into the ground using a high-rate infiltration method as illustrated in Figure 1. Located on one site, the land application systems utilize three basins. The Vineland infiltration basin (I) serves the Borough of Vineland and has been operating for approximately 50 years. The Landis Sewerage Authority has two infiltration basins, the older of which (II) has been operating for approximately 30 years and the newer (III) since 1974. In high-rate infiltration land treatment, the applied wastewater percolates through the soil and eventually reaches the groundwater. Removal of wastewater constituents such as suspended solids, BOD, and coliform is accomplished by the filtering and straining action of the soil. Nitrogen removals are generally poor unless specific operating procedures are established to maximize denitrification.

Well-drained soil, which is essential for infiltration-percolation, includes sand, sandy loams, loamy sands, and gravel. Very coarse sand and gravel are not ideal because wastewater passes too rapidly through the first few feet of soil, where the major biological action takes place. These soils are also characterized by low ion exchange capacities, which limits the chemical retention of pollutants.

The infiltration basins are located in highly permeable sand and gravel. Basins I and II were operated essentially on a continuous basis until 1974, when Basin III was constructed, and since then all basins have been alternately flooded and dried.

In this research study conducted over a one-year period, test and control plots were selected for comparison of certain parameters. Samples were collected of the sewage effluent, groundwater, and soils. Field laboratory analyses of some samples at the site and later, complete chemical laboratory analyses provided the data presented in this report.

The objective of the study was to investigate the long-term effects of applying wastewater effluent to the land. Possible health hazards of heavy metal accumulation in soils; potential contamination of groundwater supplies with bacteria, viruses, or excessive nitrates; and undesirable changes in

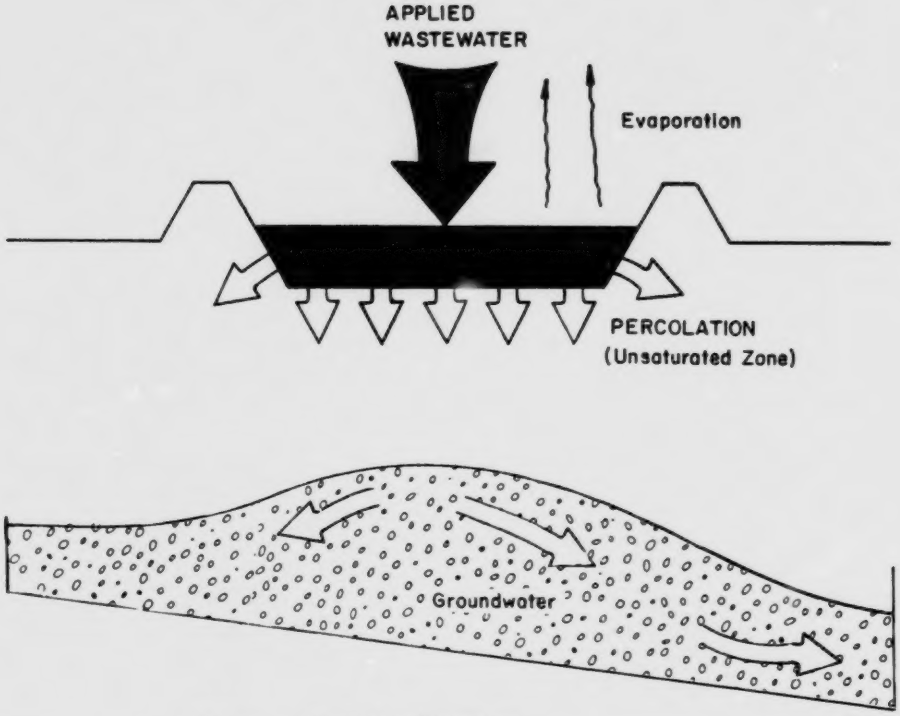

APPLIED WASTEWATER
Evaporation
PERCOLATION
(Unsaturated Zone)
Groundwater

Figure 1. Rapid infiltration.

the chemistry of the soil were key issues addressed. The study was designed to delineate the zone of groundwater influence, identify the flow path from the site, and compare on-site groundwater quality to upgradient control groundwater quality.

# SECTION 2

# CONCLUSIONS

An analysis of the waters and soils at the Vineland and Landis treatment site has produced findings related to the use of wastewater for groundwater infiltration with primary effluent applied on an essentially continuous basis for up to 50 years. Major conclusions are as follows:

1. Total and fecal coliform consistently occurred in the effluent and at depths to 6 m (20 ft) in the shallow wells beneath the basins. Total coliform occasionally occurred at the deeper depths and downgradient. Fecal coliform did not occur at depths greater than 9 m (30 ft) and occurred only one time in a shallow well 50 m (165 ft) downgradient.

   Viruses occurred in the same pattern as coliform but appeared to move deeper and further downgradient. Viruses were detected in the effluent on each sampling round and in several wells to depths of 17 m (55 ft) immediately beneath the basins on at least two rounds. They were detected once in a well 50 m (164 ft) downgradient and once in a well 250 m (820 ft) downgradient.

2. Metals such as zinc, that were measured in small concentrations in the treatment plant effluents, were removed and continue to be sufficiently immobilized by the infiltration soils after 30 to 50 years of infiltration. An apparent extraneous source of high zinc concentration was evident at Basin I but these concentrations were contained within the soils monitored for this study.

3. Iron and manganese appear to have been rendered more mobile as a result of infiltration flows. The iron concentrations in particular are extraordinarily high and must be considered at a problem level.

4. More toxic metals such as cadmium, lead and mercury were demonstrably absent in the infiltrated effluent and the underlying groundwater.

5. Lindane was found in greater than background concentrations but within the proposed national limitations for primary drinking water concentrations in both the effluent and the infiltrated groundwater.

6. Concentrations of nitrogen, phosphorus, and chemical oxygen demand

in the groundwater beneath and downgradient from the basins varied with basin service life and loading rates and were highest beneath and downgradient from Basin II. Approximately 58 percent of the applied total nitrogen concentration, 4.3 percent of the applied soluble phosphorus concentration, and 14 percent of the applied chemical oxygen demand were present in the groundwater downgradient from Basin II.

7. The phosphorus removal capability of the monitored treatment site soils near the older basin have been substantially reduced by 50 years of continuous flooding. Removal of phosphorus concentrations below 0.1 mg/L is taking place on soils beyond the area monitored for this study. Basin III continues to have phosphorus adsorption capability on immediately adjoining soils due to the comparatively young, three-year life of this basin.

8. Flow measurements and chemical anaylses of the Parvin Branch indicate that most of the infiltrated effluent moves away from the basins as groundwater but eventually enters Parvin Branch as surface water prior to its confluence with the Maurice River. A large percentage of the salient parameters in the applied effluent and downgradient groundwater could be accounted for in the surface water in Parvin Branch but were not measurable after dilution by the Maurice River.

9. Although the three basins with their different service lives and loading rates complicated the evaluation, they also offered an excellent opportunity for cross comparison and duplication of conclusions. Anomolies were found and are discussed in the text, however, the performance of the separate basins was generally quite consistent with loading rates, service life and hydrogeology.

# SECTION 3

# SITE-SELECTION PROCESS

## GENERAL CRITERIA

### Earlier Approaches

An earlier report (Bauer, 1976) defined a number of working approaches for the site-selection process. These were used initially to provide direction in the data-gathering phases. The earlier approaches included the following:

#### Soil Chemistry--

The chemical reaction of the soil with the chemicals in the applied wastewater takes place first in the upper layers of the soil. After these upper or plow layers have become saturated, reactions take place at progressively lower elevations. The distribution of accumulated chemicals resulting from the application of wastewater is studied from the point of view of this simple model of the process.

#### Hydrological--

Water moves through the earth in two major forms: (1) as soil water through the unsaturated zone, where the two fluid properties of fluid weight and surface tension dominate the movements, and (2) as groundwater through the saturated zone, where the two fluid properties of fluid weight and viscosity dominate the movements. Both of these movements are subject to the laws of fluid mechanics, permitting mathematical models to be set up for a particular site.

Such models are useful in guiding the exploratory and sampling program and in interpreting the results of such programs. The models enable one to define a "plume" of water that originates in the wastewater application site. This plume is then the only part of the soil and groundwater that is affected by the application of the wastewater. All other water outside this plume remains unaffected. This is an extremely important concept in guiding the program of sampling and in interpreting the results.

### Application to Sites

The foregoing approaches aid in defining parameters that help to distinguish one site from another. Several of these parameters are as follows:

Uniform Permeability of Soils--

Each test site and control site should have the same type of soil with the same general, reasonably uniform permeability. The soil should not contain any well-defined channels through which the applied water could escape without contact with the chemicals in the soil mass.

Same Site--

The same site should have been used for a long time. If wastewater had been applied to first one and then another site over the period of operation, the concept of the long-term effect would not be applicable.

Depth to Groundwater--

The depth to the groundwater should be sufficient to permit some movement through the unsaturated zone, yet shallow enough to allow economical sampling of the water. The thickness of the aquifer should be adequate to permit a large body of soil to react with the applied wastewater.

Accounting for Chemical Elements--

Sufficient data should be available to estimate the total mass of chemical elements applied with the wastewater, the amount percolated through the soil, and the amount that has remained in the soil.

Constant Quality--

No substantial change should have occurred in the chemical quality of the applied wastewater over the period being studied.

Extraneous Sources--

If chemicals other than those in the wastewater have been applied on the study sites, such an application can introduce uncertainties into the operation that would make the analyses difficult. Other factors being equal, sites at which other sources of chemicals have been applied should be avoided.

### General Criteria Supplied by EPA

The EPA also specified certain other general criteria for the selection of sites. These criteria are as follows:

1. Flow rates should be at least 4.38 L/s (0.1 Mgal/d).
2. Historical records should be available for at least 10 years.
3. The applied wastewater should be effluent from either primary or secondary treatment.
4. A good control site should be available within a reasonable distance and have the same general type of soil and hydrogeological conditions.

## MID-ATLANTIC STATES SITES

### Preliminary Evaluations

The geographical area involved comprised the states of Pennsylvania, New Jersey, Delaware, Maryland, Virginia, West Virginia, North Carolina, and South Carolina. STORET data supplied by the EPA were examined for information about potential sites in each of these states. A survey was conducted to obtain further information about these sites and any others that might be candidates for study. The survey showed only the sites at Vineland, New Jersey, to meet the criteria that had been established for the study. Only two states, New Jersey and Maryland, had any examples of high-rate infiltration systems using municipal effluent. One at St. Charles City, Maryland, was too new to be considered for the study. Other potential sites were eliminated for the reasons listed in Table 1.

### Vineland, New Jersey Sites

Two sites are operated at Vineland in close proximity. One was established by the City of Vineland Water and Sewer Utility Authority in the late 1920s. The other was established by the Landis Sewerage Authority in the late 1940s. Both use essentially the same approach in applying the effluent to the land and allowing it to percolate through the extensive sand deposit.

The method of application at the Landis Sewerage Authority and the Old Borough of Vineland site was altered in April, 1973. The procedure for infiltration was changed from continuous flooding to intermittent flooding. Between periods of flooding, the basin used is drained, the bottom scarified, and the soils allowed to dry before the next period of flooding.

TABLE 1. COMPARISON OF SITES LOCATED IN MID-ATLANTIC STATES[a]

| Location | Uniform Permeability | Same Site | Groundwater Depth | Aquifer Thickness | Mass Balance | Wastewater Quality | Extraneous Sources | Total |
|---|---|---|---|---|---|---|---|---|
| Vineland, N.J.[b] | +1* | 0 | 0 | +1 | +1 | +1 | 0 | 4 |

* +1 = Parameter Favorable; -1 = Parameter Unfavorable; 0 = Neutral

Notes:

a. There were surveys made of potential sites in all of the states comprising the Mid-Atlantic Region as follows:

1. No municipal infiltration treatment systems: Pennsylvania; Delaware; West Virginia; Virginia; North Carolina; South Carolina.
2. Too new: St. Charles City, Maryland.
3. Other New Jersey sites: many used for sludge drying; many abandoned.

b. The sites at Vineland are presently managed by two agencies: (1) City of Vineland Water and Sewer Utility Authority and (2) Landis Sewerage Authority. Both are contemplating a joint management of the two facilities, which are immediately adjacent to each other. For the purposes of this comparison summary, the sites managed by these two agencies are regarded as one site.

# SECTION 4

# DESCRIPTION OF SITE

## GENERAL

The City of Vineland is located in Cumberland County in southern New Jersey. This portion of south New Jersey is in the Coastal Plain physiographic province and borders the northeastern shore of Delaware Bay (Figure 2). The topography is that of a broad sand and gravel plain dissected by stream drainage into low rolling hills. This plain slopes gently toward Delaware Bay. In the vicinity of Vineland, the land surface is as much as 40 m (130 ft) above sea level; however, along the bay, tidal marshes may extend inland for five miles.

The test and control sites are in the drainage basin of the Maurice River, with the Parvin and Tarkiln Branches providing drainage from these sites to the Maurice River.

## TEST SITE

The test site is represented by two treatment facilities, which are contiguous and serve the City of Vineland as well as the surrounding area. These two facilities are considered as one test site; however, historical length of operation and treatment of effluent are different.

The infiltration basins are at an elevation of approximately 15 m (50 ft) above sea level and are in the southwestern sector of Vineland.

## CONTROL SITE

The control sites are located above the test site relative to the groundwater gradient. One control site is directly north of infiltration Basin I. Because the solid waste landfill is near, the other control site is between Basin III and the landfill. The control site areas are about 18 m (60 ft) above sea level.

## GROUNDWATER HYDROLOGY AND GEOLOGY

The Vineland area, in fact practically all of south New Jersey, is immediately underlain by unconsolidated sands and gravels. These sediments represent primarily the Cohansey Sand of Miocene-Pliocene Age (Johnson, 1950). The Cohansey is generally a medium to coarse grained quartz sand with some clay, silt, and gravel scattered throughout the formation (Rooney, 1971). Massive ironstone beds are common in the upper portion of the

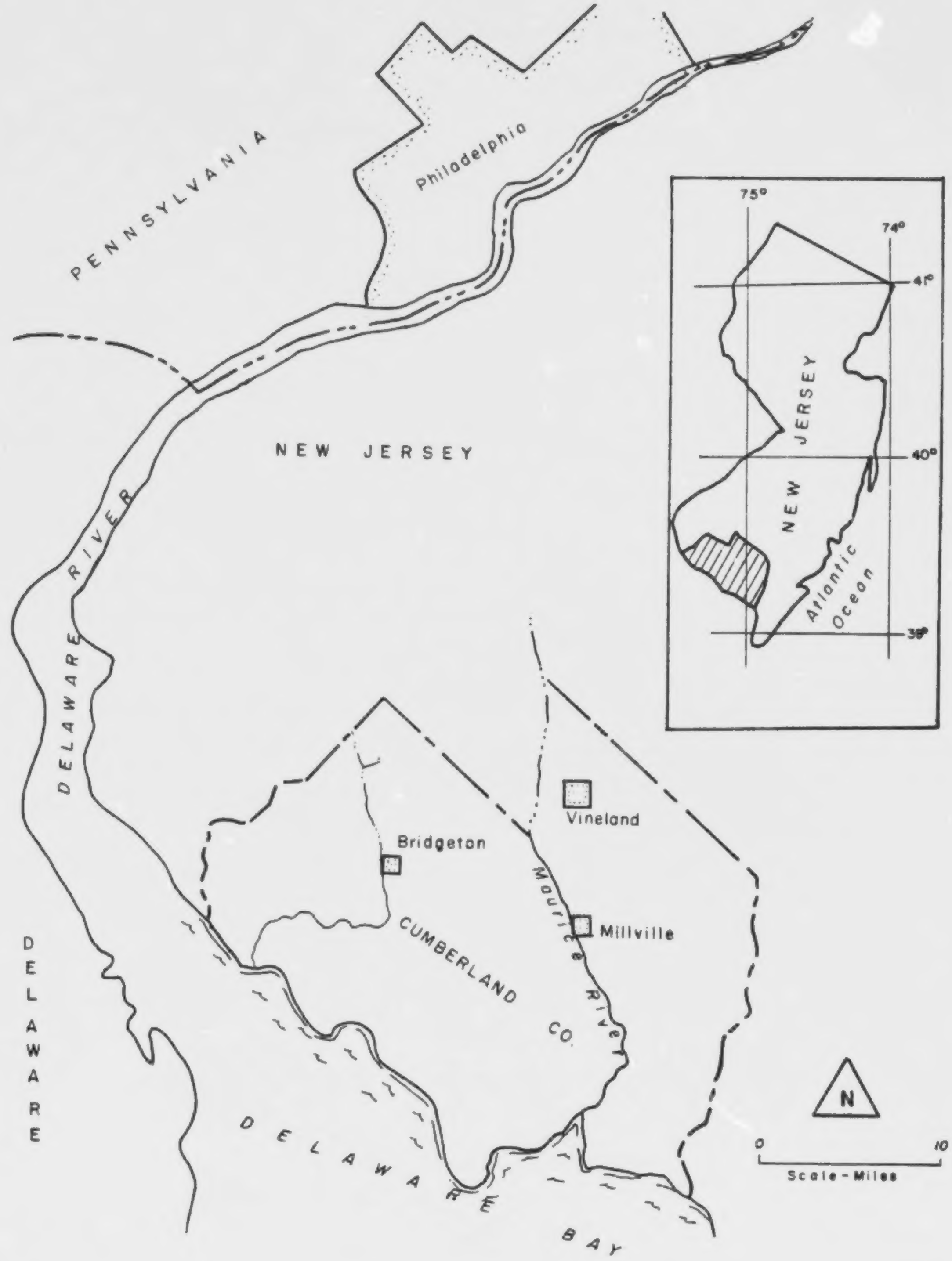

PENNSYLVANIA
Philadelphia
NEW JERSEY
DELAWARE RIVER
DELAWARE
DELAWARE BAY
CUMBERLAND CO.
Bridgeton
Vineland
Millville
Maurice River
N
0
10
Scale-Miles
75°
74°
41°
40°
39°
NEW JERSEY
Atlantic Ocean

Figure 2. Location map.

Cohansey, and the iron colors the formation causing yellow to red shades for a normally gray to buff brown color. Some carbonaceous, micaceous, silty clays are also present in the Cohansey.

On the higher ridges the Cohansey Sand is overlain by the Bridgeton Formation, which is composed of coarse gravel and sand, generally unconsolidated, of Pleistocene Age. According to the geologic map of Johnson (1950), the Bridgeton Formation does not occur in the control or test site area.

Beneath the Cohansey is the Kirkwood Formation, which crops out only in southwestern Cumberland County and probably cannot be distinguished from the sands and gravels of the Cohansey.

When the Cohansey and Kirkwood sediments are saturated with water, they combine to form the shallowest and most important source of groundwater in Cumberland County (Rooney, 1971). Even at the higher elevations in the control site area, the water table is only about 5 m (15 ft) below the ground surface, and it decreases to about 1 m (3 ft) near the Maurice River.

The water-level map for Cumberland County (Figure 3) shows the Vineland area on the southeastern side of a groundwater divide, with the regional horizontal flow direction west and southwest toward the Maurice River. This regional gradient in the Vineland vicinity has a slope of about 0.0038.

Detailed water-level contours for August and December, 1976, are shown on Figures 4 and 5, respectively. These two maps show essentially the same overall trends; however, there was a mound beneath Landis Basin III in August, 1976 (Figure 4) that was not evident in December, 1976 (Figure 5). These changes were due to the wastewater loading schedule for the infiltration basins and rainfall. The groundwater movement from Basin I is to the west-southwest into the Maurice River. From Basin II the groundwater moves to the south into the Parvin Branch or to the southwest into the Maurice River. Groundwater movement from Basin III is to the south into the Tarkiln and Parvin Branches.

The water-level contours suggest that the groundwater quality of all three basins could be affected by the solid waste landfill. The groundwater gradient slope from these two maps is about 0.0034. Permeabilities reported for the Cohansey sand range from 5.66 x $10^{-2}$ $cm^3$ per sec per $cm^2$ (1200 gpd per $ft^2$)(Rosenau et al., 1969) to 1.27 x $10^{-1}$ $cm^3$ per sec per $cm^2$ (2,700 gpd per $ft^2$) (Rooney, 1971). Using the above slope and range for coefficient of permeability, and assuming an effective porosity of 15 percent, the rate of horizontal groundwater movement ranges from 1 to 2.5 m (3 to 8 ft) per day. This means that infiltration wastewater at Basin I probably requires from 17 to 36 months to reach the Maurice River.

The sample descriptions for the Cohansey Formation (Appendix A) do not indicate much clay; however, the results of the pump tests suggested the existence of clay lenses. For instance, the pump test well was screened at 60 cm (2 ft) intervals from 9 to 12 m (30 to 40 ft). An observation

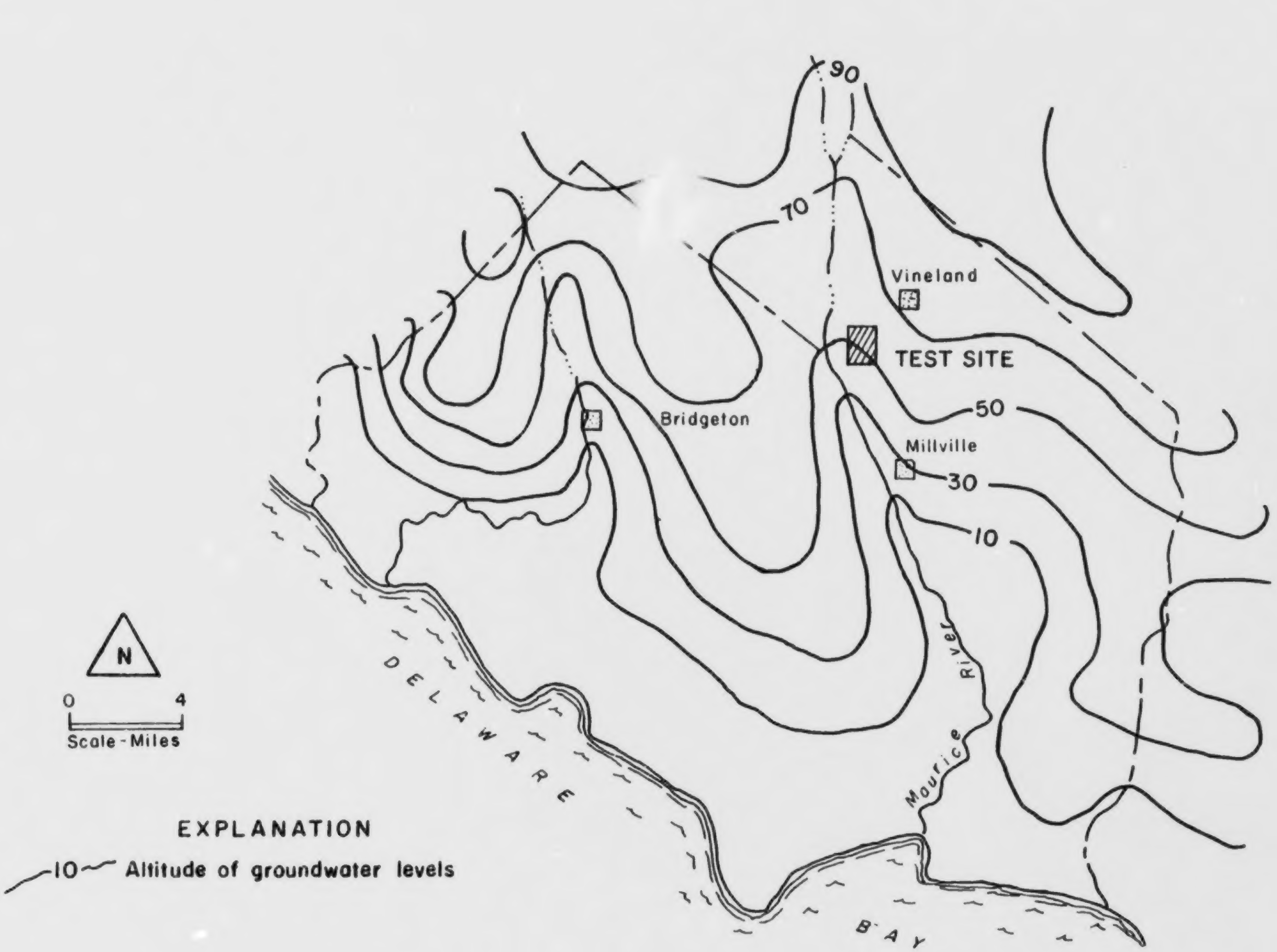

90
70
50
30
10
Vineland
TEST SITE
Millville
Bridgeton
Maurice River
DELAWARE
BAY
N
0
4
Scale-Miles
EXPLANATION
10 Altitude of groundwater levels

Figure 3. Groundwater level contours, Cumberland Co., New Jersey. From Rooney, 1971

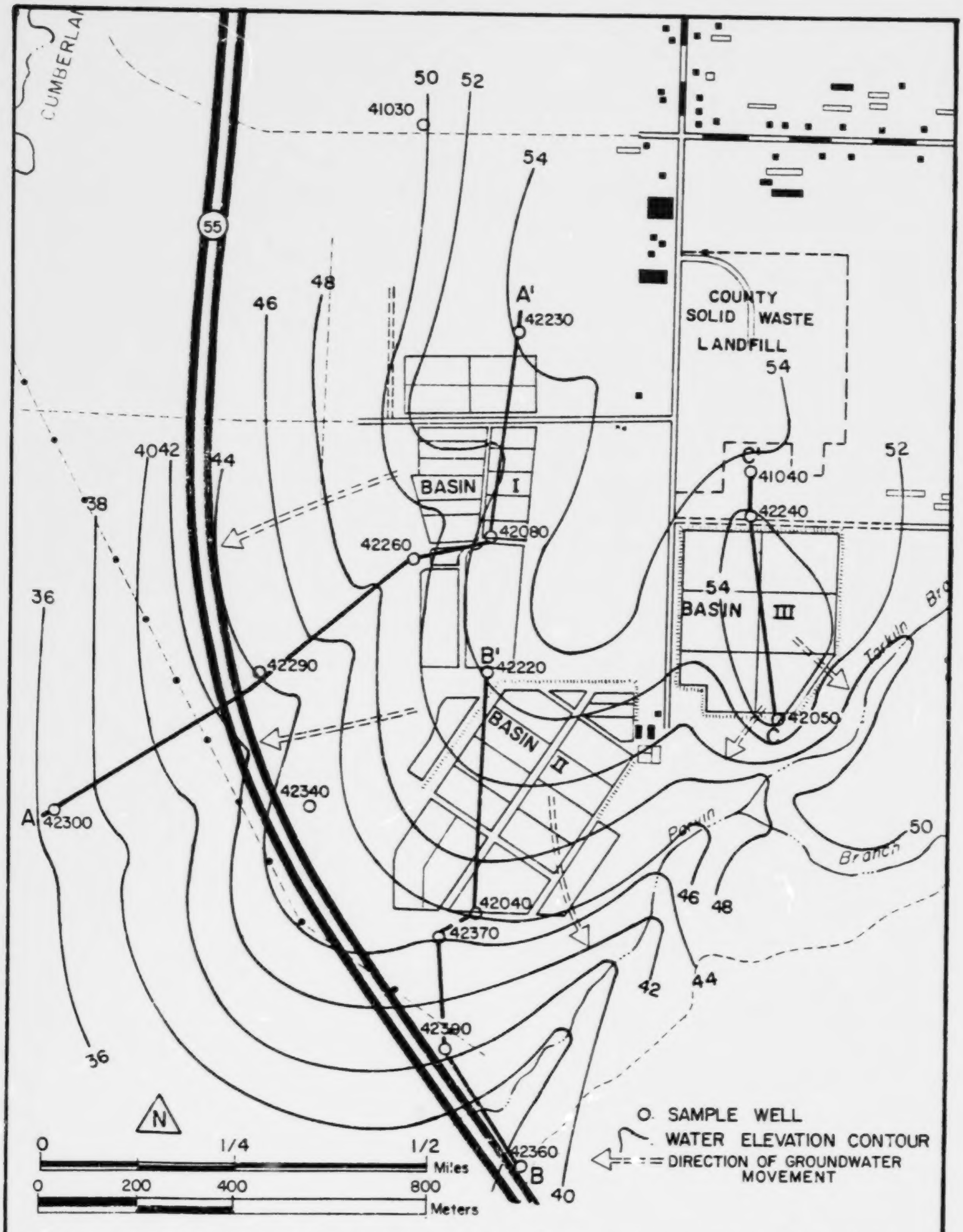

CUMBERLA
55
50
52
41030
54
A'
42230
COUNTY SOLID WASTE LANDFILL
54
46
48
40
42
44
38
36
BASIN I
42080
42260
C'
41040
52
42240
54
BASIN III
Tarkiln Br
B'
42220
42290
BASIN II
42050
C
42340
A
42300
Parvin
Branch
50
46
48
42370
42040
42
44
42380
36
N
0
1/4
1/2
Miles
0
200
400
800
Meters
42360
B
40
SAMPLE WELL
WATER ELEVATION CONTOUR
DIRECTION OF GROUNDWATER MOVEMENT

Figure 4. Water elevation contours, August, 1976, and cross section locations.

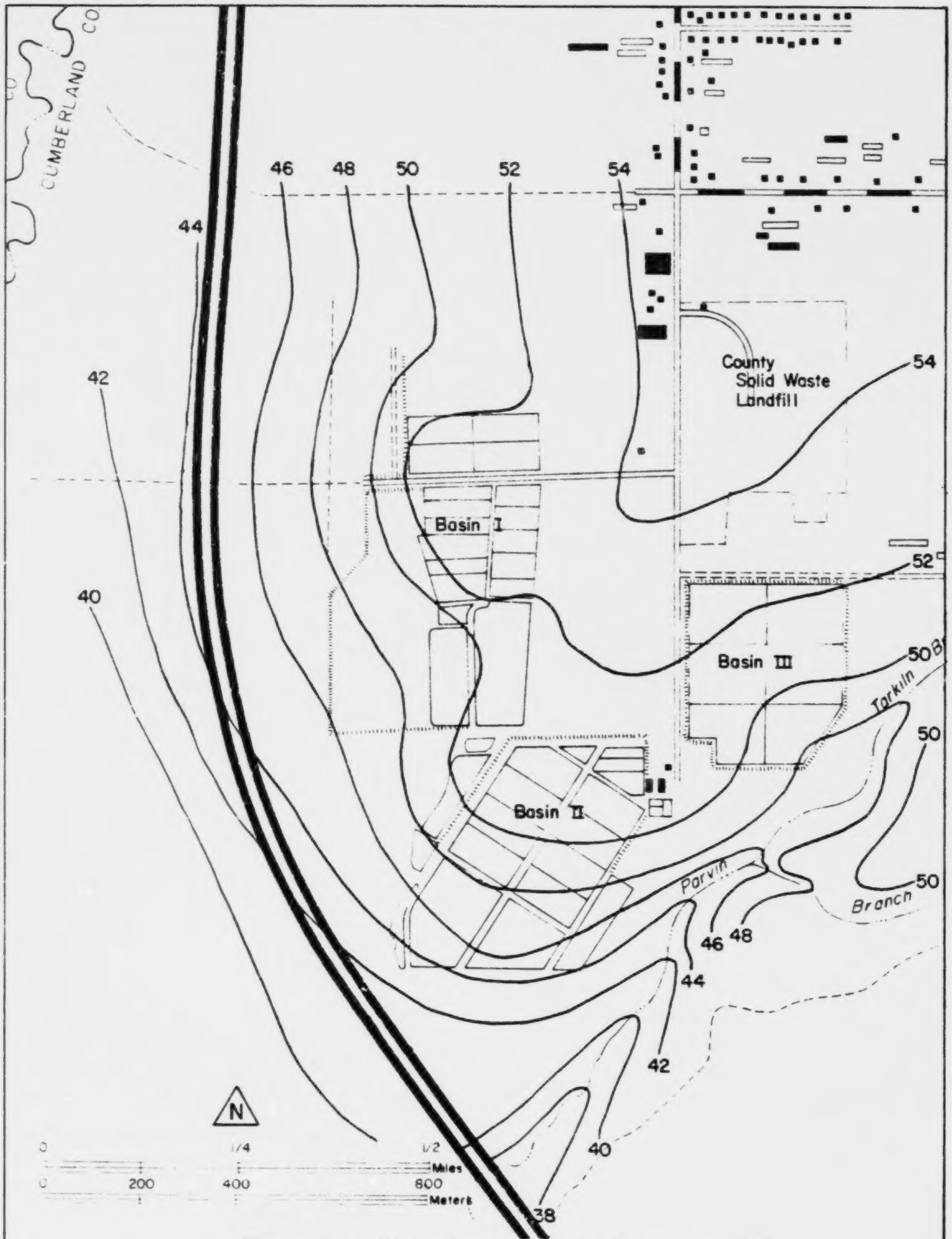

CUMBERLAND CO
46
48
50
52
54
44
42
40
County Solid Waste Landfill
54
Basin I
52
Basin III
50
Tarkiln Br
50
Basin II
Parvin
Branch
50
46
48
44
42
40
38
N
0
1/4
1/2
Miles
0
200
400
800
Meters

Figure 5. Water level contours, December, 1976.

well located 3.6 m (12 ft) away was screened from 3.4 to 4.3 m (11 to 14 ft) (Figure 4). During a pump test the observation well showed no drawdown, but well 42290, screened 14 to 15 m (46 to 50 ft) and located 9 m (30 ft) from the pump well, did show drawdown. This suggests that one or more clay lenses retarded vertical communication in the aquifer.

## SURFACE WATER

The major surface stream in the Vineland study area is the Maurice River. The Parvin and Tarkiln Branches provide minor drainage and enter the Maurice River southwest of the study site (Figure 6). The flow was measured in the Maurice River above Landis Avenue and below Sherman Avenue in August, 1976. The flow increased from about 1,950 to 3,200 L/s (69 to 113 ft$^3$/s) between the two stations (Table 2). Very little of this increased flow was a result of the confluence with the Parvin Branch, but 425 to 570 (15 to 20 ft$^3$/s) may have resulted from the Muddy Run Branch. The major flow increase was probably due to groundwater inflow. Flow measurements were made during a relatively low flow period, because the average discharge at the USGS gaging station at Norma is 4,650 L/s (164 ft$^3$/s) for the years 1932 to 1970.

The Tarkiln and Parvin Branches showed increased flow rates downstream that cannot be totally accounted for by tributary inflow. This increased flow was predominantly due to groundwater inflow. The groundwater inflow into the Tarkiln Branch is primarily from the direction of the test site infiltration basins and from the landfill.

Field observation of the Tarkiln Branch suggested that inflow into the stream was influenced by the infiltration basins. Along the west side of Tarkiln Branch opposite Basin III, red-orange iron bacteria flourish, but this phenomenon does not occur on the east bank. Measurements at station 42460 showed a higher conductivity on the west bank. The iron bacteria continue to be very prominent downstream into lower Parvin Branch. From station 42470 to station 42520, iron bacteria cover nearly all the vegetation and projections in the stream, and the water conductivity measurements are high.

The upper Parvin Branch, stations 42450 and 42480, is a clear stream with observed fish, healthy vegetation, and no iron bacteria. The conductivity measurements are low, and there seems to be no evidence of infiltration basin or landfill pollution. Water analyses and visual observation at station 42440 on the Tarkiln Branch did not show evidence of pollution. The measured flow is low; hence groundwater inflow is low in comparison with downstream flow, which is affected by the artificial mounding of the groundwater table beneath Basin III. Between stations 42440 and 42490, the stream flow increased by 52 L/s (1.82 ft$^3$/s) or 1.18 Mgal/d. In contrast, the flow in the Parvin Branch, which does not appear to be affected by Basin III, decreases 0.12 Mgal/d along a similar reach between stations 42450 and 42480.

The increase in flow between stations 42490 and 42470 minus the tributary flow at station 42480 is 0.14 Mgal/d; the increase between stations 42470 and 42520, located just below Basin II, is 0.61 Mgal/d.

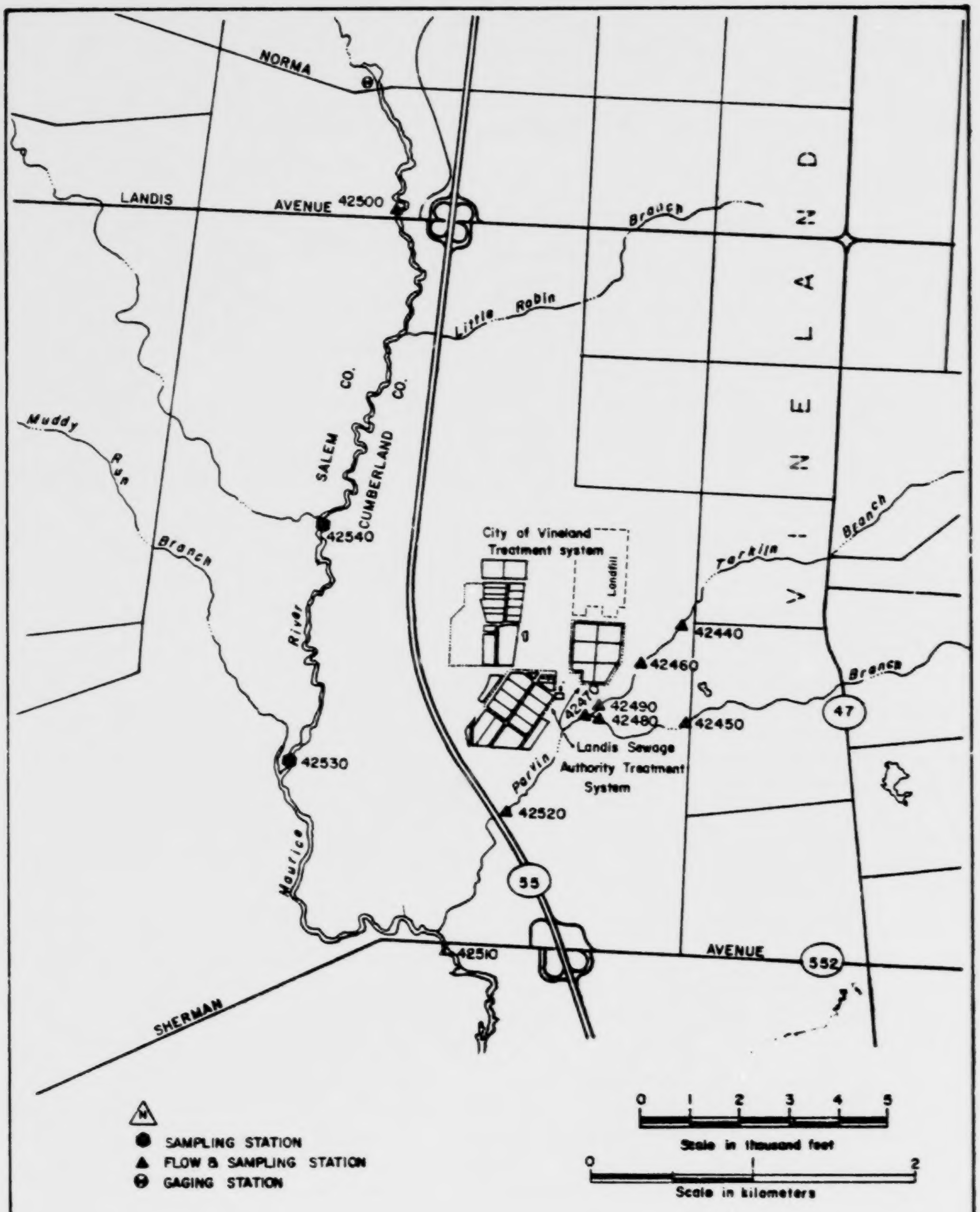

NORMA
LANDIS
AVENUE
42500
Branch
Little Robin
SALEM CO.
CUMBERLAND CO.
V I N E L A N D
Muddy Run
Branch
42540
City of Vineland Treatment system
Landfill
Tarkiln
Branch
42440
42460
42470
42490
42480
42450
Branch
47
Landis Sewage Authority Treatment System
River
42530
Parvin
42520
Maurice
55
AVENUE
552
42510
SHERMAN
N
SAMPLING STATION
FLOW & SAMPLING STATION
GAGING STATION
0
1
2
3
4
5
Scale in thousand feet
0
1
2
Scale in kilometers

Figure 6. Vineland, N.J. stream flow measuring and sampling stations

TABLE 2. SUMMARY OF FLOW MEASUREMENTS ON MAURICE RIVER, PARVIN AND TARKILN BRANCHES

| Flow Station Number | Date | Width (Feet) | Depth (Feet) | Flow (cfs) | Temperature (°C) | Conductivity (μmhos/cm) | Color | Remarks |
|---|---|---|---|---|---|---|---|---|
| **MAURICE RIVER** | | | | | | | | |
| 42500 | 8-26-76 | 37.5 | 1.82 | 68.82 | 22 | 75 | Clear | Landis Avenue |
| 42510 | 8-26-76 | 51 | 4.0 | 113 | 24 | 90 | Clear | Sherman Avenue |
| **TARKILN BRANCH** | | | | | | | | |
| 42440 | 8-24-76 | 3.2 | 0.25 | 0.27 | 23 | - | Clear | Elm Road |
| 42460 | 8-25-76 | 8.4 | 0.26 | 1.21 | | | | East of Landis Basin III |
| | | | | | 20 | 185 | - | East side of stream |
| | | | | | - | 290 | - | West side of stream; red-orange iron bacteria; floating chunks of iron bacteria. |
| 42490 | 8-25-76 | 7.4 | 0.58 | 2.09 | 18 | 350 | - | Above confluence with Parvin Branch; floating iron bacteria prevalent. |
| **PARVIN BRANCH** | | | | | | | | |
| 42450 | 8-25-76 | 7.0 | 1.05 | 1.51 | 18 | 129 | Clear | Orchard Road |
| 42480 | 8-25-76 | 6.9 | 0.75 | 1.32 | 20 | 135 | Clear | Above confluence with Tarkiln Branch; vegetation, fish. |
| 42470 | 8-25-76 | 14.5 | 0.39 | 3.62 | 19 | 305 | - | Below confluence with Tarkiln Branch; boggy bottom, no fish, iron bacteria cover everything. |
| 42520 | 8-31-76 | 9.2 | 1.23 | 4.56 | 21 | 370 | Damage tint | Highway 55; chunks of floating iron bacteria. |

Although there was no groundwater inflow upstream at this time, there would likely be some natural groundwater inflow along the lower reaches investigated. Even so, it is obvious that much of the 1.8 Mgal/d increase in flow in the Parvin Branch above station 42520 is the result of wastewater infiltration at Basins II and III.

The flow of the Parvin and Tarkiln Branches is quickly diluted by the large flow in the Maurice River. At station 42510 there is no evidence of iron bacteria, and the conductivity is low.

## SOILS

The soils at the Vineland study site have been formed from materials of glacial origin and are characteristically deep, sandy, and well drained. The surface is nearly level to gently sloping terrain. Around the wastewater site, soils belonging to the Eavesboro, Lakewood, and Lakehurst Series are dominant. These series have rapid permeability, ranging from 5 to >20 cm/hr (2 to >6 in/hr), and low available soil water capacity; they are well drained, loose, and low in fertility and organics. The upper soils appear bleached gray in color with a profile depth greater than 18 cm (7 in) thick. The subsoils and substratum are yellowish brown and composed of sands and gravel materials. At the test site, the continual leaching in the infiltration beds has long since removed any diagnostic soil horizons. The water table is generally less than 3 m (10 ft) below the surface.

The test site basins are not vegetated and are scarified following each inundation with wastewater. The control site is vegetated with mixed pine and oak with an understory of shrubs and bushes. In reality, this soil is not a soil system as typically defined, but a quartz sand filter for the groundwater.

A typical profile of the soil representative of the control site and of the test site in its virgin state follows:

A1-0-8 cm (0-3 in); very dark grayish brown consisting of a mixture of dark organic matter and clean white sand grains; sand is single grained, loose; few small and medium roots present; strongly acidic; clear wavy boundary.

C1-8-25 cm (3-10 in); yellowish brown single grains of sand, loose when moist, nonsticky when wet; small and medium roots present; strongly acidic; gradual wavy boundary.

C2-25-110 cm (10-43 in); yellowish brown single grained, clear sand grains; loose consistency with commonly medium pores and root channels present; structureless; few small roots present; strongly acidic; gradual wavy boundary.

C3-110-160 cm (43-63 in); yellowish brown with a few splotches of very pale brown color; sands are loose, clear single grains; few large pores; strongly acidic; gradual wavy boundary.

C4-160-200 cm (63-79 in); very pale brown with a few common distinct yellowish red mottles; single grained, loose when moist; clear; strongly acidic.

## Infiltration Rate Test

During the third sampling round in March, 1977, an infiltration rate test of the test and control site soils was conducted. Cylinder-type infiltrometers were employed, using a method similar to that described by Haise et al (1956).

A set of three cylinders was used for the tests. The cylinders were filled to a predetermined point, and measurements were made at the end of 1, 3, 5, 10, 20, 30, 45, 60, 90, 120, and 180 minutes. The infiltrometers were refilled as required to bring the water level back to the original mark. The test site measurements were made in Basin II, adjacent to wells 42030, 42040, and 42170 through 42210. The control site measurements were made adjacent to wells 41010 through 41030. The steady state conditions at the end of two hours of testing on the control and test sites soils indicated an infiltration rate of about 130 cm/hr (51 in/hr) and 15.8 cm/hr (6.2 in/hr), respectively.

## CLIMATE

Cumberland County has a humid temperate climate moderated by the Delaware Bay and the Atlantic Ocean. The average annual temperature and precipitation data are given in Table 3.

Summer temperatures do not exceed 38° C (100° F) for long periods but are frequently in the range from 33 to 37° C (91 to 98° F). Winter temperature generally are not below -15° C (5° F) for long periods. The ground is normally not frozen throughout the winter.

The average annual precipitation is 102 to 112 cm (40 to 44 in), and the monthly averages in Table 3 indicate that precipitation is well distributed. In nearly every year there are periods when there is not enough rainfall for high-value crops. Rainfall is heaviest in June and July with much of the rainfall occurring in summer as thunderstorms. The largest amount of rainfall recorded in a 24-hour period is 25.4 cm (9.99 in.). In winter, the rainfall frequently warms the soils enough to thaw any frozen ground.

The wind is mainly from the northwest, with its duration and velocity greatest during the month of March.

The length of the growing season in the county is about 193 days. The average date of the last killing frost in spring is about April 15, and that of the first in fall is October 25.

Recent climatological data for the period of field sampling are shown in Table 4.

### TABLE 3. TEMPERATURE AND PRECIPITATION DATA[a]

| | Temperature | | | | Precipitation | | |
|---|---|---|---|---|---|---|---|
| | | | Two years in 10 will have at least 4 days with-- | | | One year in 10 will have-- | |
| Month | Average daily maximum (°F) | Average daily minimum (°F) | Maximum temperature equal to or higher than-- (°F) | Minimum temperature equal to or lower than-- (°F) | Average total (Inches) | Less than-- (Inches) | More than-- (Inches) |
| January | 46 | 27 | 55 | 6 | 2.9 | 0.7 | 4.8 |
| February | 44 | 25 | 59 | 9 | 2.8 | 1.6 | 4.2 |
| March | 51 | 31 | 68 | 20 | 3.8 | 2.0 | 5.7 |
| April | 62 | 40 | 82 | 30 | 3.1 | 1.3 | 5.7 |
| May | 73 | 51 | 88 | 39 | 3.2 | 0.9 | 5.9 |
| June | 82 | 60 | 92 | 50 | 3.1 | 0.7 | 5.3 |
| July | 87 | 66 | 96 | 58 | 3.9 | 0.9 | 7.7 |
| August | 85 | 64 | 91 | 53 | 4.4 | 1.4 | 9.3 |
| September | 77 | 56 | 88 | 45 | 3.1 | 0.6 | 6.8 |
| October | 69 | 47 | 81 | 32 | 2.7 | 0.6 | 5.0 |
| November | 56 | 35 | 68 | 24 | 3.5 | 1.3 | 5.9 |
| December | 46 | 27 | 59 | 13 | 3.6 | 1.4 | 6.2 |
| Year | 65 | 44 | 97[b] | 2[c] | 40.1 | 32.8 | 56.5 |

[a] All data based on records at Millville FAA Approach, Millville, New Jersey.

[b] Average annual highest temperature.

[c] Average annual lowest temperature.

TABLE 4. RECENT CLIMATOLOGICAL DATA

| Month | Average Temp.[a] (°F) | Precipitation[a] (inches) | Evaporation[b] (inches) |
|---|---|---|---|
| January, 1976 | 29.3 | 4.18 | ------ |
| February, 1976 | 41.3 | 1.90 | ------ |
| March, 1976 | 45.5 | 1.70 | ------ |
| April, 1976 | 54.3 | 1.04 | ------ |
| May, 1976 | 60.8 | 2.69 | 6.19[c] |
| June, 1976 | 73.2 | 1.89 | 7.45[c] |
| July, 1976 | 74.2 | 2.29 | 8.12[c] |
| August, 1976 | 73.3 | 3.10 | 6.91[c] |
| September, 1976 | 66.7 | 3.01 | 4.58[c] |
| October, 1976 | 51.8 | 4.90 | ------ |
| November, 1976 | 39.8 | 0.50 | ------ |
| December, 1976 | 31.1 | 2.65 | ------ |
| Total, 1976 | 53.4 | 29.85 | 33.25[c] |
| January, 1977 | 21.9 | 2.20 | ------ |
| February, 1977 | 34.2 | 1.07 | ------ |
| March, 1977 | 48.0 | 3.00 | ------ |
| April, 1977 | 54.9 | 2.54 | ------ |
| May, 1977 | 64.1 | 0.80 | 7.23 |
| June, 1977 | 68.9 | 2.36 | 7.41[c] |
| Total, Jan-June 1977 | 48.7 | 11.97 | 14.64 |

[a] Measured at Millville FAA Approach at Millville, New Jersey.

[b] Measured at New Brunswick, New Jersey.

[c] Adjusted to a full month.

## LAND USE

Farm acreage in Cumberland County, which includes Vineland, decreased from a high of 40 percent in 1940 to about 30 percent by 1969. Although the number of farms has decreased, sizes of individual farms have increased. In 1969, the average size of a farm was 53 ha (130 acres); about 27,000 ha (67,000 acres) was in crops, and of this more than 8,100 ha (20,000 acres) was irrigated.

The main crop is vegetables grown for freezing; they include snap beans, onions, and cabbage, among others.

In 1967, hardwood and pine forests comprised about 45 percent of the land area of the county. Most of the extensive woodland is not considered a part of farms.

# SECTION 5

# PLANT OPERATION AND COSTS

For this project the two treatment systems in operation serving the Vineland area were studied as one site. The Vineland system serves the original development in the borough. The Landis Sewerage Authority serves the remainder of the developed portions of Vineland and nearby communities.

## BOROUGH OF VINELAND TREATMENT PLANT

The treatment facility owned and operated by the Borough of Vineland presently serves a total estimated population of 5,850 persons. The average daily flow to the Vineland plant for the first eight months of 1974 was 35 L/s (0.80 Mgal/d). The capacity of the plant is 66 L/s (1.5 Mgal/d). The plant provides primary treatment of the wastewater before it is discharged onto infiltration beds. The area of the beds is about 9.7 ha (24 acres). Primary treatment includes coarse screening of the influent and primary settling tanks. Sludge drawn off from the sedimentation compartment of the settling tanks is discharged to sludge drying beds twice a year, and the dried sludge is then plowed under.

There are no major industrial contributors to the City of Vineland plant, but at various times the wastewater contains oil from spills from the power plant and large concentrations of syrup wastes from the Limpert Company, a soda syrup manufacturer.

## LANDIS SEWERAGE AUTHORITY TREATMENT PLANT

The Landis Sewerage Authority's existing treatment plant served a total estimated population of approximately 19,000 persons in 1974, with an average daily flow of 180 L/s (4.1 Mgal/d). The treatment facility has an average daily design flow capacity of 310 L/s (7.0 Mgal/d), providing primary treatment through an influent pumping station, pre-aeration chamber, and primary settling tank. The final effluent is discharged onto infiltration beds. Sludge from the primary settling tanks is pumped to a sludge-holding tank and processed by chemical oxidation and stabilization before being pumped to open drying beds; dried sludge is disposed of by stock-piling on the existing plant property. Infiltration Basins II and III, presently being utilized for the plant effluent, comprise a total area of 26.3 ha (65 acres). Basin II has been used since 1948, while Basin III has been used since 1974.

Almost 50 percent of the total flow contributed to the Landis Sewerage Authority System is from industrial sources. The three major industrial contributors and their daily average flows are:

1. Progresso - 26 to 53 L/s (0.59 to 1.21 Mgal/d).
2. Venice Maid - 26 to 44 L/s (0.59 to 1.00 Mgal/d).
3. Manischewitz Food Products - 7 to 11 L/s (0.16 to 0.25 Mgal/d).

Maximum industrial flows occur during the canning season, which lasts for about four months of the year. Other wastes received at the plant on occasion have a pH above 8 due to caustic spills, high chloride concentrations, and excessive quantities of oil and grease.

## WASTEWATER CHARACTERISTICS

Wastewater characteristics measured in 1974 were as indicated in Table 5.

TABLE 5. WASTEWATER CHARACTERISTICS

| Parameter (mg/L) | Vineland | Landis |
|---|---|---|
| $BOD_5$ | 306 | 638 |
| COD | 510 | 799 |
| Total Kjeldahl Nitrogen | 37.9 | 34.1 |
| Orthophosphate | 11.3 | 10.0 |
| Suspended Solids | 273 | 209 |

## INFILTRATION OF WASTEWATER

The Borough of Vineland infiltration site, Basin I, has been in operation since 1928. The Landis Sewerage Authority Basin II has been in operation since 1948 and Basin III since 1974. Basins I and II were operated by the continous flooding technique from their initial use until April, 1973, when the operation was changed to intermittent flooding. Basin III has been operated by the intermittent flooding technique since its initial use.

The present operation is to flood the beds by either pumping or gravity flow, depending upon location. The flow to each bed is controlled by shear gates, and the flow is distributed at the higher end of each bed until the level in the bed reaches about 45 cm (18 in). As this level in each bed is attained, flow is diverted to the next bed. The length of time that each bed is flooded varies, depending on volume of flow and the soil percolation rate.

After the wastewater has percolated through the soil, the entire bed is normally scarified in order to loosen the soil and enhance the permeability of the top layer. Every six months, each bed is plowed to a depth of 30 cm (12 in), mixing the soil and organic matter that has been filtered during the percolation of the wastewater.

## OPERATING COSTS

The Landis Sewerage Authority Report of Audit for 1976 reported the following for operation of its sewage collection and treatment system:

| | |
|---|---|
| Operating Revenues | $1,348,771 |
| Minus Operating Expenses | 331,468 |
| Net Revenues | $1,017,303 |
| Minus Debt Service | 196,391 |
| Net Income for Year 1976 | $ 820,912 |

The 1976 Annual Report for the City of Vineland reported sewer revenues of $160,703, expenses of $40,362 and net income of $120,341.

# SECTION 6

# RESEARCH METHODS

## WELL CONSTRUCTION AND LOCATIONS

### Well Construction

Test-hole and sample-well construction was done by one or a combination of the following drilling methods: (1) eight-inch hollow-stem auger, (2) powered, three-inch hand auger, (3) jet with city water. The hollow-stem auger was used for the deeper holes, with the casing and screen placement through the hollow stem of the auger. While the auger method provides marginal information about the sediments because of the mixing that occurs as the sample travels up the auger flights, major lithological changes, such as clay layers or gravel beds, could frequently be noted by a change in the penetration rate and the rotation rate of the auger. Drive core samples were generally taken every 3 m (10 ft) and at suspected formation changes.

Although the auger does not provide the most useable lithological data, it does allow the placement of well screens with minimal contamination. The auger flights were withdrawn after placement of the well casing, allowing the hole to cave around the screen and casing. However, there was generally 10 or more feet of open hole after withdrawal of the auger flights, and half a sack of bentonite (25 pounds) was poured around the casing. The rest of the hole was backfilled with augered material and the top of the hole sealed with the remainder of the sack of bentonite.

Shallow holes were constructed with a powered, three-inch hand auger. The hole was augered to the desired depth or slightly deeper, the auger withdrawn, and casing with screen pushed to the selected depth. This technique worked well for the very shallow holes; however, it was sometimes necessary to jet the casing with screen to the selected depth. In such cases, Vineland city water was used as the jetting water. Completion of the hole was similar to that for the hollow-stem auger holes.

During construction, chlorinated water was added to the drill hole after the water table had been reached or to the jetting water when wells were jetted in. After construction, the wells were again chlorinated and pumped for several hours to ensure that any contamination or water introduced during construction was pumped out.

The aboveground construction included a six-inch diameter steel casing and lockable lid, pushed about two feet into the ground to protect the casing (Figure 7). This procedure was not used on any of the wells constructed

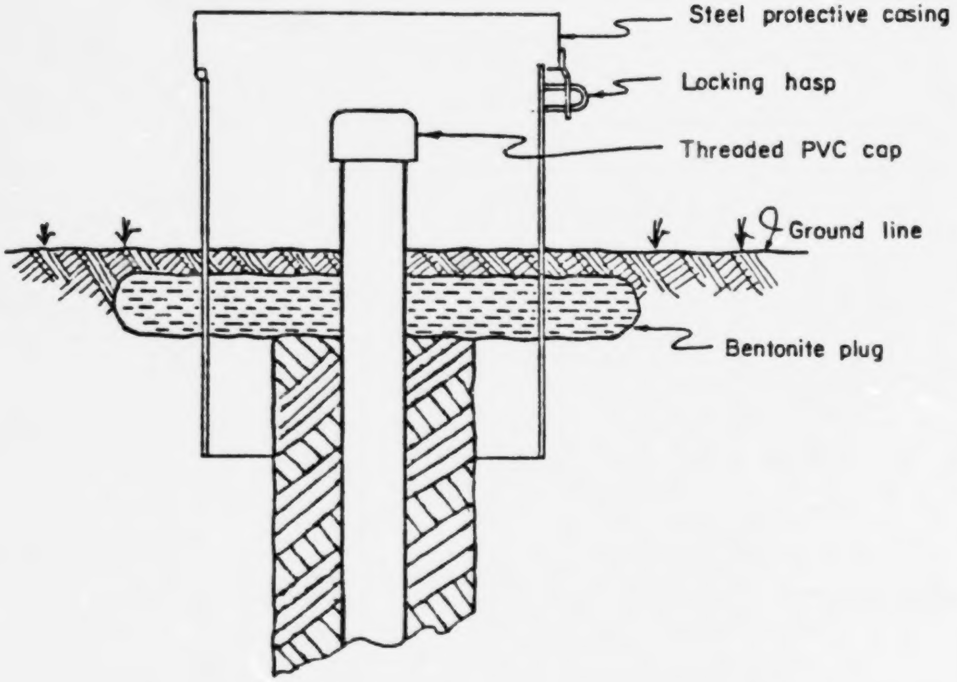


Figure 7. Typical aboveground construction

within the infiltration basins, as protection within the basin was considered unnecessary and steel casing would be a source of metal contamination in the water-saturated environment of the basin.

For this study, seven test holes, six control site wells, 36 test site wells, and two pump test observation wells were constructed. These wells ranged in depth from 0.6 to 21 m (2 to 69 ft) (Table 6). A description of the sediments encountered and the particulars of well construction are given in Appendix A.

Figure 8 shows the locations of the six control site wells, three test holes, one upstream test site well, and seven downstream test site wells. The remainder of the test site wells, test holes, and existing Landis Sewerage Authority wells are shown on Figure 9.

Groundwater Samples

Prior to sampling, the wells were carefully bailed to remove the volume of water in the casing and then a dissolved oxygen sample was collected and fixed in the field. Wells were chlorinated with a calcium hypochlorite solution, which was circulated through the well and sampling pump, then

TABLE 6. WELL SUMMARY TABLE

| WELL NUMBER | TOTAL DEPTH (Ft below G.L.) | SCREEN DEPTH (Ft. below G.L.) | PUMPING RATE (G.P.M.) | TOP OF CASING (Ft. above G.L.) | ELEV. TOP OF CASING (m.s.l.) | ELEV. S.W.L. (m.s.l.) August, 1976 | S.W.L. (Ft. below T.O.C.) August, 1976 | S.W.L. (Ft below T.O.C.) December 10, 1976 | S.W.L. (Ft below T.O.C.) March 3, 1977 | S.W.L. (Ft. below T.O.C.) May 27, 1977 | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 41010 | 50 | 45-49 | 1 | 1.02 | 63.42 | 50.29 | 13.13 | 12.8 | 12.77 | 12.77 | |
| 41020 | 35 | 30-34 | 20 | 1.02 | 63.81 | 50.23 | 13.58 | 12.8 | 13.01 | 13.21 | |
| 41030 | 30 | 26-30 | 3 | 1.01 | 63.56 | 50.18 | 13.38 | 13.0 | 12.9 | 13.02 | |
| 41040 | 21.5 | 19-21 | 10 | 0.85 | 67.16 | 53.55 | 13.61 | 14.25 | --- | 14.07 | |
| 41050 | 60 | 56-60 | 50 | 0.94 | 67.15 | 53.26 | --- | --- | 13.89 | 14.16 | |
| 41060 | 40 | 36-40 | 50 | 1.06 | 67.26 | 53.57 | --- | --- | 13.67 | 14.02 | |
| | | | | | | | | | | | |
| 42020 | 9.5 | 7-9 | -- | 1.05 | 55.53 | 49.46 | 6.07 | 5.26 | --- | 6.08 | |
| 42030 | 30 | 26-30 | 25 | 1.01 | 54.77 | 46.5 | 8.27 | 8.78 | 8.79 | 10.35 | |
| 42040 | 8 | 6-8 | 2 | 3.08 | 51.94 | 46.67 | 5.27 | 5.85 | 5.81 | 5.83 | |
| 42050 | 30 | 25-29 | 12 | 0.92 | 64.76 | 50.43 | 14.33 | 15.49 | 15.0 | 15.4 | |
| 42060 | 60 | 58-60 | 16 | 0.73 | 57.64 | 50.64 | 7.0 | 6.98 | 6.81 | 7.19 | |
| 42070 | 4 | 2-4 | -- | 1.95 | 58.81 | 52.88 | 5.93 | 5.94 | 5.79 | 5.96 | |
| 42080 | 7 | 5-7 | 2 | 1.88 | 58.67 | 52.29 | 6.38 | 6.32 | 5.66 | 6.91 | |
| 42090 | 16 | 14-16 | 9 | 1.76 | 58.51 | 52.27 | 6.24 | 6.16 | 5.51 | 6.75 | |
| 42100 | 22 | 20-22 | 16 | 1.95 | 58.59 | 52.26 | 6.33 | 6.22 | 5.6 | 6.83 | |
| 42110 | 45 | 41-45 | 2 | 0.8 | 57.90 | 51.68 | 6.22 | 5.86 | 5.4 | 6.87 | |
| 42120 | 4 | 2-4 | -- | 2.0 | 61.91 | --- | DRY | DRY | DRY | DRY | |
| 42130 | 7 | 5-7 | -- | 2.09 | 62.04 | --- | DRY | DRY | DRY | DRY | |
| 42140 | 11 | 9-11 | -- | 1.99 | 61.98 | 54.67 | 7.31 | DRY | DRY | DRY | |
| 42150 | 17 | 15-17 | 10 | 2.0 | 62.03 | 54.27 | 7.76 | 14.06 | 13.4 | 13.96 | |
| 42160 | 70 | 65-67 | 12 | 0.88 | 64.90 | 50.35 | 14.55 | 15.62 | 15.29 | 15.63 | |
| 42170 | 4 | 2-4 | 3 | 2.43 | 51.41 | 46.68 | 4.73 | 5.3 | 5.18 | 5.88 | |
| 42180 | 6 | 4-6 | 2 | 2.88 | 51.94 | 46.67 | 5.27 | 5.85 | 5.84 | 6.52 | |
| 42190 | 12 | 10-12 | 11 | 3.1 | 51.92 | 46.64 | 5.28 | 5.87 | 5.87 | 6.53 | |

(Continued)

TABLE 6. (Continued)

| WELL NUMBER | TOTAL DEPTH (Ft. below G.L.) | SCREEN DEPTH (Ft. below G.L.) | PUMPING RATE (G.P.M.) | TOP OF CASING (Ft. above G.L.) | ELEV. TOP OF CASING (m.s.l.) | ELEV. S.W.L. (m.s.l.) August, 1976 | S.W.L. (Ft. below T.O.C.) August, 1976 | S.W.L. (Ft. below T.O.C.) December 10, 1976 | S.W.L. (Ft. below T.O.C.) March 3, 1977 | S.W.L. (Ft. below T.O.C.) May 27, 1977 | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 42200 | 16 | 14-16 | 11 | 2.87 | 51.99 | 46.66 | 5.33 | 5.9 | 5.92 | 6.55 | |
| 42210 | 55 | 51-55 | 25 | 1.01 | 54.49 | 44.71 | 9.78 | 10.48 | 9.6 | 10.09 | |
| 42220 | 9 | 7-9 | 5 | 0.98 | 57.42 | 52.11 | 5.31 | 5.84 | --- | 6.75 | |
| 42230 | 28 | 26-28 | 10 | 0.91 | 67.83 | 54.18 | 13.65 | 15.0 | 15.13 | 15.94 | |
| 42240 | 15 | 13-15 | 3 | 1.03 | 67.17 | 53.95 | 13.22 | 13.71 | 5.71 | 14.13 | |
| 42250 | 25 | 23-25 | 6 | 0.92 | 67.02 | 53.81 | 13.21 | 13.64 | --- | 13.7 | |
| 42260 | 8 | 6-8 | 5.5 | 1.02 | 55.50 | 49.46 | 6.04 | 5.23 | 5.07 | 6.04 | |
| 42270 | 8 | 6-8 | 1.8 | 0.96 | 50.78 | 44.14 | 6.64 | 5.56 | 5.73 | 6.42 | |
| 42280 | 30 | 26-30 | 50 | 1.12 | 50.37 | 43.95 | 6.42 | 5.38 | 5.51 | 6.19 | |
| 42290 | 50 | 46-50 | 15 | 1.16 | 50.67 | 44.19 | 6.48 | 5.6 | 5.68 | 6.3 | |
| 42300 | 5 | 3-5 | 2 | 0.92 | 41.13 | 37.38 | 3.75 | 4.2 | 4.4 | DRY | |
| 42310 | 12 | 10-12 | 16 | 1.0 | 41.16 | 37.42 | 3.74 | 2.94 | 3.1 | 3.68 | |
| 42350 | 45 | 40-45 | 30 | 0.66 | 43.39 | 34.55 | 8.84 | 2.89 | 3.11 | 3.68 | |
| 42360 | 34.5 | 30-34 | 7 | 1.15 | 47.28 | 38.39 | 8.89 | 8.68 | 8.73 | 8.97 | |
| 42370 | 9 | 7-9 | 6 | 1.04 | 48.12 | 43.92 | 4.2 | 4.3 | 4.64 | 5.56 | |
| 42380 | 16.5 | 14-16 | 3 | 0.99 | 45.48 | 40.59 | 4.89 | 4.37 | --- | 5.19 | |
| 42390 | 35 | 30-35 | 14 | 1.0 | 45.96 | 41.53 | 4.43 | 4.81 | --- | 4.75 | |
| 42400 | 55 | 50-54 | 10 | 1.05 | 46.05 | 40.82 | 5.23 | 3.88 | --- | 5.36 | |
| | | | | | | | | | | | |
| OBS1* | 40 | 30-32<br>34-36<br>38-40 | 80-100 | 0.75 | 50.37 | 44.64 | --- | --- | 5.73 | 6.16 | |
| OBS2* | 15 | 11-15 | 80-100 | 0.64 | 50.27 | 44.57 | --- | --- | 5.70 | 5.76 | |
| | | | | | | | | | | | |
| L-9 | LSA | Test Well | | 0.55 | 67.39 | 54.12 | --- | --- | 13.27 | DRY | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

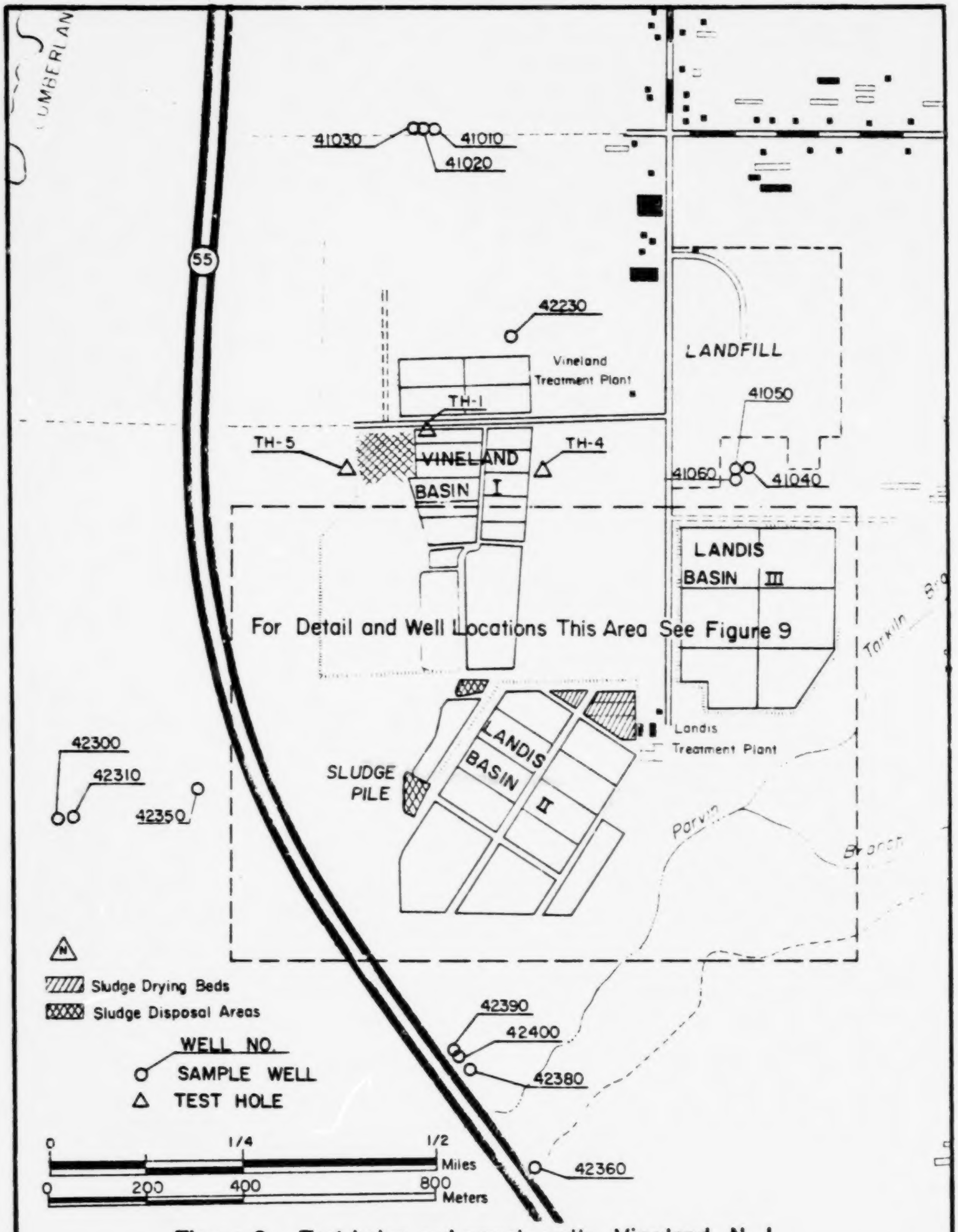
*Pump Test Wells

(Continued)

TABLE 6. (Continued)

| WELL NUMBER | TOTAL DEPTH (Ft. below G.L.) | SCREEN DEPTH (Ft. below G.L.) | PUMPING RATE (G.P.M.) | TOP OF CASING (Ft. above G.L.) | ELEV. TOP OF CASING (m.s.l.) | ELEV. S.W.L. (m.s.l.) August, 1976 | S.W.L. (Ft. below T.O.C.) August, 1976 | S.W.L. (Ft. below T.O.C.) December 10, 1976 | S.W.L. (Ft below T.O.C.) March 3, 1977 | S.W.L. (Ft. below T.O.C.) May 27, 1977 | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TH1 | | | | 0.8 | 57.00 | 52.36 | 4.64 | 4.33 | 4.93 | 3.54 | |
| TH2 | | | | 1.27 | 58.14 | 50.56 | 7.58 | 13.08 | 13.35 | 7.48 | |
| TH3 | 25 | 23-25 | 8 | 0.98 | 66.68 | 53.68 | 13.0 | 13.87 | 13.03 | 13.46 | Also well 41070 |
| TH4 | 19.5 | 17-19 | 7 | 1.0 | 67.35 | 52.81 | 14.54 | 14.94 | 14.79 | 14.46 | |
| TH5 | 13.5 | 11.5-13.5 | 15 | 0.84 | 51.35 | 48.68 | 2.67 | 1.44 | 2.05 | 2.29 | |
| TH7 | 14 | 12-14 | 16 | 1.15 | 55.26 | 51.21 | 4.05 | 4.23 | 3.33 | 5.17 | |
| TH8 | 11.5 | 9.5-11.5 | 15 | 0.97 | 50.80 | 44.12 | 6.68 | 5.64 | 5.77 | 6.46 | |
| | | | | | | | | | | | |
| R-1* | 25 | 20-25 | | | 64.00 | 53.3 | 10.7 | --- | --- | --- | |
| R-2* | 25 | 20-25 | | | 52.76 | 45.46 | 7.3 | --- | --- | --- | |
| R-3* | 25 | 20-25 | | | 51.86 | 44.04 | 7.82 | --- | --- | --- | |
| R-4* | 80 | 75-80 | 7 | | 49.79 | 44.19 | 5.6 | 5.22 | --- | 6.11 | Also well 42340 |

*Water level recorder wells installed by Landis Sewerage Authority.



UMBERLAN
55
41030
41010
41020
42230
Vineland Treatment Plant
LANDFILL
41050
TH-1
TH-5
VINELAND BASIN I
TH-4
41060
41040
LANDIS BASIN III
For Detail and Well Locations This Area See Figure 9
Tarkiln Br
LANDIS BASIN II
Landis Treatment Plant
SLUDGE PILE
Parvin Branch
42300
42310
42350
N
Sludge Drying Beds
Sludge Disposal Areas
WELL NO.
SAMPLE WELL
TEST HOLE
42390
42400
42380
42360
0
1/4
1/2
Miles
0
200
400
800
Meters

Figure 8. Test holes and sample wells, Vineland, N. J.

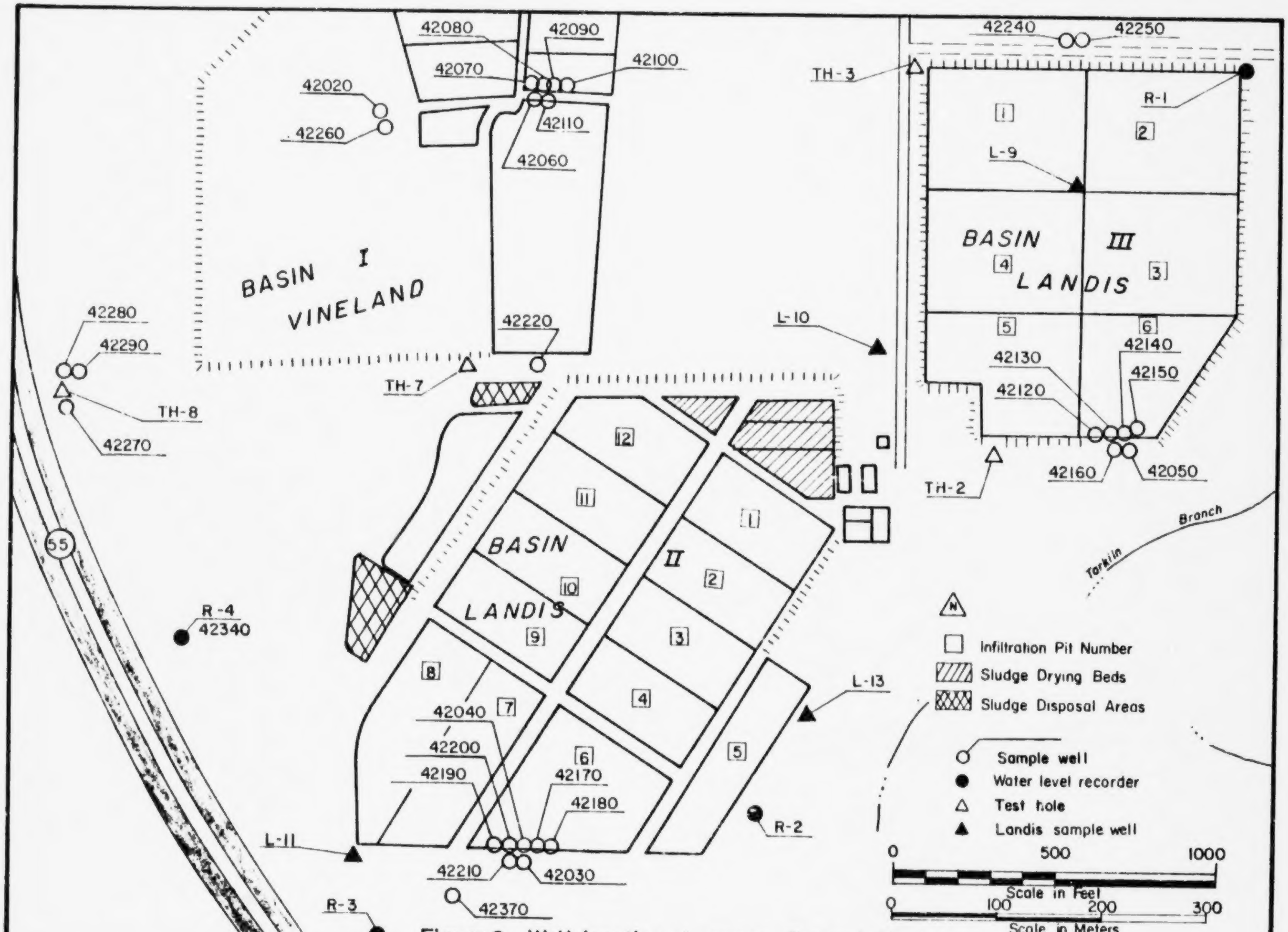

BASIN I VINELAND
BASIN II LANDIS
BASIN III LANDIS
42020
42260
42080
42070
42090
42100
42110
42060
42220
42240
42250
R-1
L-9
TH-3
TH-2
TH-7
TH-8
42280
42290
42270
L-10
42130
42140
42120
42150
42160
42050
Tarkiln Branch
R-4
42340
55
42040
42200
42190
42170
42180
42210
42030
42370
L-11
R-3
R-2
L-13
1
2
3
4
5
6
7
8
9
10
11
12
N
Infiltration Pit Number
Sludge Drying Beds
Sludge Disposal Areas
Sample well
Water level recorder
Test hole
Landis sample well
0
500
1000
Scale in Feet
0
100
200
300
Scale in Meters

Figure 9. Well location at sewage disposal plant.

pumped and rinsed until the water showed no residual chlorine by the ortho-tolidine test. Samples were collected through a centrifugal pump.

The same personnel performed all sampling on the four rounds. At each sampling point, a field sheet recording form was completed that noted the time of collection, method of sampling, length of time the well was pumped, and any pertinent field conditions.

The typical procedure was for the sampling team personnel to collect about six water samples per day in prepared kits. Each kit consisted of several sample bottles and polyethylene containers to which preservatives had already been added. After the sampling team had collected several samples, the filled kits were returned to the field laboratory for analyses. Normally the time between collection of the sample and delivery to the field laboratory did not exceed two hours.

### Effluent Samples

A 24-hour composite sample consisting of four grab samples was collected at each treatment plant outfall on each sampling round.

### Soil Samples

Composite soil samples were collected twice from the control sites and from each infiltration basin of the test site. Composite test site samples were obtained by combining a number of individual core samples collected from the same depth from the infiltration basins. Composite control samples were collected using the same procedure from areas located upgradient from the test site basins. The sample cores were taken for three depth increments: 0 to 31 cm (0 to 12 in), 95 to 105 cm (37 to 41 in), and 295 to 305 cm (116 to 120 in).

During the warm season (August, 1976), composite soil samples were collected from each of the infiltration basins and a control site adjacent to and upgradient from each basin to represent the same soil type and profile. Also, soil drive core samples were taken from 3 to 3.7 m (10 to 12 ft) in wells 42260 and 42280 and from 7.6 to 8.2 m (25 to 27 ft) in well 42290. During the cool season (March, 1977), composite soil samples were collected from each of the infiltration basins and from a control sub-area site located adjacent to control wells 41010 through 41030.

### Virus Samples

Water was collected from the sample wells and the effluent discharge of the treatment plant in polyethylene-lined 208 L (55 gal) drums and transported to the field laboratory by truck. The wells, pump, hoses, and drums were sterilized with calcium hypochlorite solution and then rinsed until no residual chlorine was detected by the ortho-tolidine test prior to taking samples.

At the field laboratory, viruses were concentrated by using a virus concentrator as illustrated in the 14th edition of Standard Methods, Section 913 A (American Public Health Association, 1976). The concentrator utilizes the general principle of acidification of the sample, adsorption of the viruses onto a filter, and subsequent readjustment of the pH, allowing elution of the viruses into the concentrated sample.

During round 2 (December, 1976), samples were also concentrated using the bentonite technique developed by the U.S. Army Bioengineering Research and Development Laboratory, Ft. Detrich, MD (Schaub, 1977).

The final concentrate was air shipped to the assay laboratory on dry ice.

### Virus Assaying Procedures

In the laboratories the water samples were assayed for viruses, and neutralization tests were performed on selected isolates to identify the viruses by using buffalo green monkey kidney (BGMK) cell monolayers, human embryonic lung (HEL) cells, or primary baboon (PB) cells for cytopathic effect (Lenette, 1969).

Samples exhibiting cytotoxicity were retested, after centrifugation at 3,000 rpm for 10 minutes, by filtration through a 0.45 µm filter and two hours of adsorption at 37° C (99° F) during continual rotation.

If plaques became visible, they were counted, plucked, and grown for identification in either BGMK, PB, or HEL cells, depending on the cell line in which they were first isolated.

## CHEMICAL AND BIOLOGICAL ANALYSES

Samples collected in the field at the control and test sites were either analyzed at the field laboratory or returned to the laboratory in Oklahoma City, Oklahoma, for analyses. The time-critical parameters were analyzed in the field as soon as the samples were collected. For those samples designated for later laboratory analyses the standard methods for preservation relevant to the parameter to be analyzed were employed. In the following sections the methods used in the analyses of water and soil samples are presented in sequence. Field methods are discussed prior to laboratory methods. A summary is given in Table 7 of the field method changes that were made during the sampling program to overcome equipment and methodology problems.

### Methods for Analyses of Water

#### Field Analyses--

Alkalinity (total)--Water samples were titrated with a 0.02 N sulfuric acid solution to an end point of pH 4.5. An exactly prepared 0.02 N solution of sodium carbonate was used to standardize the sulfuric acid and was used in spiking water samples (APHA, 1976).

Ammonia--Ammonia analyses were performed with the use of an ammonia electrode. A standard curve was constructed from 1000, 100, 10, 1, and 0.1

TABLE 7. SUMMARY OF FIELD METHODS

| | Sampling Trip | | | |
|---|---|---|---|---|
| Analysis | Vineland I | Vineland II | Vineland III | Vineland IV |
| Alkalinity (Total) | Potentiometric Titration | Potentiometric Titration | Potentiometric Titration | Potentiometric Titration |
| Ammonia | Probe | Probe | Probe | Probe |
| BOD | Probe | Probe | Probe | Probe |
| Chloride | Probe | Tritration | Titration | Titration |
| Coliform (Total) | Membrane Filter | Membrane Filter | Membrane Filter | Membrane Filter |
| Coliform (Fecal) | Membrane Filter | Membrane Filter | Membrane Filter | Membrane Filter |
| Conductance | Meter | Meter | Meter | Meter |
| D.O. | Winkler | Winkler | Winkler | Winkler |
| Nitrate | Probe | Cadmium Reduction | Cadmium Reduction | Cadmium Reduction |
| Nitrogen (Kjeldahl) | Digestion & Probe | Digestion & Probe | Digestion & Probe | Digestion & Probe (Modified) |
| Orthophosphate (Soluble) | Single Reagent | Single Reagent | Single Reagent | Single Reagent |
| pH | pH Electrode | pH Electrode | pH Electrode | pH Electrode |
| Phosphorus (Soluble) | Filtration, Digestion, & Single Reagent | Filtration, Digestion, & Single Reagent | Filtration, Digestion, & Single Reagent | Filtration, Digestion, & Single Reagent |
| Phosphorus (Total) | Digestion & Single Reagent | Digestion & Single Reagent | Digestion & Single Reagent | Digestion & Single Reagent |
| Sulfide | Probe, No Preservative | Probe, No Preservative | Probe With Preservative | Probe With Preservative |
| Sulfate | Probe | Turbidimetric | Turbidimetric | Turbidimetric |

mg/L solutions of stock ammonium chloride. The samples and standards were treated identically. The electrode was immersed into the sample, and 10 N sodium hydroxide was added to raise the pH. The millivolt reading was recorded, and the ammonia concentration was determined directly from the calibration curve (Orion IM, 1975a, and Bremner, 1972).

Biochemical oxygen demand--Dissolved oxygen (DO) in water samples was determined with a DO meter prior to setting up biochemical oxygen demands ($BOD_5$). The meter was air-calibrated with an aneroid barometer according to manufacturer's instructions. Air calibrations were periodically checked against the Winkler method. The samples were diluted with aerated dilution water according to the results obtained from initial experimentation. In some samples no dilutions were required. The initial DO was measured directly in the BOD bottle. The bottles were then carefully glass-stoppered and plastic caps placed over the mouths of the bottles to prevent loss of water from the water seal. The samples were prepared in duplicate and incubated at $20^{0}$ C in the dark for five days. The final DO was also measured with the probe. Samples containing chlorine were treated with sodium thiosulfate to eliminate the chlorine and then seeded with 24-hour-old domestic wastewater. Glucose-glutamic acid checks were performed to observe the efficiency of the BOD procedures (APHA, 1976).

Coliform (total)--Field samples were collected in sterile glass bottles. Samples were thoroughly mixed, and 1 mL was taken with a sterile pipette and passed through a 0.45 μm Gelman filter. Beginning with sampling rounds three and four, one 50 mL sample was also run. All equipment was sterilized by immersion in boiling water. The filter was aseptically placed on a filter pad containing 2 mL Endo Broth in a 50 x 12 mm plastic petri dish. The dishes were placed into a whirlpac plastic bag, inverted, and incubated at $35^{0}$ C for 24 hours in a bacteriological incubator. The typical coliform colonies counted had a pink to dark red color with metallic surface sheen (APHA, 1976).

Coliform (fecal)--The procedure was identical to that for total coliforms with the exception of medium. The medium used was mFC, and plates were not inverted. Plates were incubated at $44.5^{0}$ C for 24 hours. Typical coliform colonies were small and blue (APHA, 1976).

Conductivity--Determination of specific conductance was performed using a conductivity meter. Using a potassium chloride solution of known conductance, the meter was calibrated prior to running analyses. Specific conductance values were corrected to $25^{0}$ C by using multiplication factors (APHA, 1971).

Dissolved oxygen--At the well site, immediately after pumping the well, dissolved oxygen was measured by the azide modification of the Winkler method. One Hach powder pillow each of manganous sulfate, alkaline-iodide-azide, and sulfamic acid was added to the water sample. The sample was then brought to the field laboratory and titrated with phenylarsine oxide (PAO) using a starch indicator (APHA, 1976).

Nitrate nitrogen--Samples from round one were analyzed for nitrate with the use of the nitrate electrode. The probe was immersed in the sample and the final millivolt reading was recorded. Nitrate concentrations were determined from a standard curve prepared from standards serially diluted from a potassium nitrate stock solution.

Due to the inability to recover spikes and uncontrolled drift in millivolt readings in certain samples, the nitrate probe was replaced with the cadmium reduction column method for sampling rounds two, three, and four. The samples were flocculated and/or filtered through a 0.45 μm Gelman filter prior to analyses. An aliquot of sample was passed through a column containing granulated copper-cadmium to reduce nitrate to nitrite. Columns were reactivated between field trips and at other times when efficiency dropped. The nitrite (that originally present plus reduced nitrate) was reacted with the color reagent to form a highly colored azo dye, which was measured spectrophotometrically at 420 nanometers (nm). The nitrite was then determined in the sample and subtracted from the initial value to obtain nitrate (USEPA, 1974; Orion IM, 1975b; and Orion IM, 1976c).

Nitrogen (total and soluble organic)--A micro-Kjeldahl digester and an ammonia electrode were used for analyses. Procedural changes were made throughout the field trips in an attempt to correct the problem of not obtaining total nitrogen recovery. A 50 mL aliquot of sample (filtered for soluble, not filtered for total) was boiled in the presence of concentrated sulfuric acid, potassium sulfate, and mercuric sulfate, and evaporated one-half hour past the disappearance of sulfurous acid fumes. Rounds one, two, and three samples were analyzed by adding 10 N sodium hydroxide to the sample and recording the millivolt reading from the ammonia probe. For the first three rounds, the mercury interference in the digestion reagent was not identified before testing for ammonia. This resulted in an ammonia-mercury complex formation and low nitrogen results. Experiments in the laboratory showed that addition of 2 N sodium iodide with the 10 N sodium hydroxide did not effectively eliminate the mercury interference. Beginning with round four, two major changes were made: 1) Hengar crystals, which are selenium coated, replaced mercury as the catalyst and 2) samples were partially neutralized with sodium hydroxide and allowed to cool in an ice bath prior to ammonia analyses to compensate for heat gained from addition of the sodium hydroxide to acid. Excellent results were obtained, using the final revised procedures (Orion IM, 1975a, and Bremner, 1972).

Orthophosphate (soluble)--Orthophosphate phosphorus was determined by the single reagent method. Samples were filtered through a 0.45 μm Gelman filter. The pH of the sample was adjusted to 7.0 ± 0.2 with sodium hydroxide. Ammonium molybdate, antimony potassium tartrate, and ascorbic acid color reagent were added to the sample and read in the manner described for total phosphorus (USEPA, 1974).

pH--Hydrogen ion concentration (pH) was determined by use of a glass combination pH electrode. The meter was calibrated for pH determinations by using buffers of pH 4, 7, and 10 (APHA, 1976).

Phosphorus (total)--Phosphorus was determined by the single reagent method. Sulfuric acid (11 N) and ammonium persulfate were added to the samples. Samples were boiled gently followed by pH adjustment to pH 7.0 ± 0.2 with sodium hydroxide. Ammonium molybdate, antimony potassium tartrate, and ascorbic acid color reagent were added to the samples. The blue color formed was read at 640 nm using a spectrophotometer. The phosphorus concentration was determined from a standard curve that was prepared from serial dilutions made from a stock phosphorus solution (USEPA, 1974).

Sulfide sulfur--Analyses for sulfide were made with a sulfide electrode. Procedural changes involving sulfide anti-oxidant buffer (SAOB) and standards were a result of additional research by Orion (Orion IM, 1976a).

Samples for rounds one and two were brought to the field laboratory, where an aliquot of sample was added to an equal volume of 50 percent SAOB. The SAOB contained sodium hydroxide, sodium salicylate, and ascorbic acid. The calibration curve was prepared from a standard consisting of sodium sulfide, sodium hydroxide, sodium salicylate, and ascorbic acid. The standard was titrated against a 0.1 M lead perchlorate solution to obtain the exact normality. Standards and samples were treated identically except standards were prepared by diluting in 25 percent SAOB. The electrodes were immersed in the sample, and the millivolt reading was recorded after it stabilized. The exact concentration of sulfide was determined from the standard curve (Orion IM, 1975c).

Samples for rounds three and four were added directly to plastic bottles half filled with 50 percent SAOB in the field. The SAOB contained sodium hydroxide, disodium ethylenediaminetetraacetic acid (EDTA), and ascorbic acid. The calibration curve was prepared from a standard consisting of sodium sulfide and SAOB. The standard was titrated against 0.1 M lead perchlorate to find the exact normality of the standard. This solution was then serially diluted to prepare a standard curve. The samples and standards were treated identically. The electrodes were immersed in the sample, and millivolt readings were recorded. The exact concentration of sulfide was determined from the standard curve (Orion IM, 1976a).

Laboratory Analyses--

Boron--Boron was analyzed by the curcumin method. Samples were added to evaporating dishes made of boron-free glass. Curcumin reagent was added, and the dishes were placed in a water bath set at 55 ± 2° C and evaporated to dryness. The contents of each dish were redissolved in 95 percent ethyl alcohol, filtered through Whatman 30 filter paper, and read at 540 nm on a spectrophotometer. The boron concentration was determined from a standard curve, which was prepared from standards serially diluted from a 100 mg/L boron stock solution (APHA, 1976).

Chemical oxygen demand--Samples were collected in plastic bottles containing sulfuric acid as a preservative and kept on ice until the analyses were completed. The dichromate reflux method was used for chemical oxygen demand (COD) determinations. The alternate procedure for dilute samples in which the potassium dichromate and ferrous ammonium sulfate are more dilute, was used for low level COD samples (USEPA, 1974).

Chloride--Analyses for chlorides for the first round were performed with a chloride electrode. Due to problems with this electrode, sample analyses of rounds two, three, and four were completed by the mercuric nitrate titration method. Hach powder pillows (prepared indicator-acidifier reagent) were used as the indicator for rounds two and three, but the indicator-acidifier reagent was used for round four (APHA, 1971).

Prior to running analyses with a chloride electrode, standard curves were prepared from serially diluted standards of a 100 mg/L sodium chloride stock solution. Standards and samples were treated identically. The electrodes were immersed in samples with ionic strength adjuster (ISA) added. Samples were mixed at a constant rate on a magnetic stirrer until stable millivolt readings were observed. Using millivolt readings, unknown concentrations were determined from the calibration curve (Orion IM, 1976b).

Samples for titration were adjusted to a pH of 2.5 with nitric acid, and indicator-acidifier reagent was added to the sample, which was then titrated with 0.0141 N mercuric nitrate. If high chlorides were present, 0.141 N mercuric nitrate was used as the titrant. The samples were titrated to a light purple end point. Iron, which acts as an interference, was removed from the sample through flocculation with zinc sulfate solution and sodium hydroxide. The floc was allowed to settle and was filtered through a 0.45 micron filter. Analyses were performed on the filtrate (APHA, 1976).

Herbicides--Field samples were collected in hexane-rinsed, glass-stoppered bottles. Chlorinated phenoxy acid herbicides were extracted from the acidified water sample with diethyl ether. The ether layer was filtered through anhydrous sodium sulfate into hexane-rinsed bottles, 37 percent potassium hydroxide was added, and the sample was returned to the laboratory for analyses. Water was added to the sample and the ether removed by evaporation. Extraneous organic matter was removed by extracting the basic aqueous phase with diethyl ether. The aqueous phase was acidified to hydrolyze the esters to acids and the acids extracted with diethyl ether. Benzene was added and the solution evaporated to 0.5 mL in Kuderna-Danish evaporators.

The acids were esterified to methyl esters with 0.5 mL boron trifluoride in methanol. The benzene layer was shaken with neutral 5 percent sodium sulfate solution. The benzene extracts were further purified by passing through Florisil columns. Identification and quantification of the esters were made by gas-liquid chromatography and were corroborated through the use of two or more unlike columns (USEPA, 1971).

Metals (total)--Metal analyses were performed by atomic absorption spectrophotometry. Field samples were collected in plastic bottles and preserved with nitric acid to a pH 2. Two bottles were preserved for each sample. Round four samples were filtered at the well site through a 1 μm filter. All metals except for arsenic, selenium, and mercury were prepared by cautiously digesting with nitric acid and evaporating to dryness. Samples were refluxed with nitric acid and brought back to volume, then subjected to the standard conditions and instrumental parameters for the corresponding metals (USEPA, 1974; Martin, 1975; and Atomic Absorption Methods Manual, 1975).

Mercury was analyzed by the cold vapor technique. Concentrated sulfuric acid, concentrated nitric acid, 5 percent potassium permanganate, and potassium persulfate were added, and samples were heated 2 hours at 95° C in a water bath. Sodium chloride and hydroxylamine hydrochloride were added to samples. The mercury was vaporized by adding stannous sulfate (USEPA, 1974).

Arsenic and selenium were determined by atomic absorpiton, using a heated graphite atomizer and electrodeless discharge lamps. The samples were digested with nitric acid and hydrogen peroxide. Nickle nitrate was added to the digested samples prior to analysis (Martin, 1975).

Organic carbon (total and soluble)--Soluble organic carbon samples were filtered through a 0.45 micron Gelman filter and kept iced until prepared for analyses. Total organic carbon samples were not filtered. Purging and sealing of the ampules were done in the field. Ten mL glass ampules were prepared by adding 0.2 g potassium persulfate to 5 mL of sample and 0.5 mL of 3 percent phosphoric acid. Samples were then purged with oxygen. Phosphoric acid was prepared daily and added to the ampules just prior to sealing. Samples were prepared in triplicate. Carbon dioxide-free water was used for the blanks. Tests were performed in the laboratory to determine optimum length of time for purging and combusting the samples. The organic matter in the ampules was oxidized in a pressure vessel that was placed in an oven heated to 175° C for 16 hours.

After oxidation, the samples were analyzed with a carbon analyzer (USEPA, 1974, and Oceanography International IM, 1971).

Pesticides--Field samples were collected in hexane-rinsed, glass-stoppered bottles. Organochlorine pesticides were extracted from the water with an 85:15, hexane: methylene chloride solvent mixture in the field. The organic layer was filtered through anhydrous sodium sulfate into hexane-rinsed bottles and returned to the laboratory for analysis. The organochlorine pesticides analyzed were endrin, lindane, methoxychlor, and toxaphene. Extracted samples were concentrated in Kuderna-Danish evaporators in a hot water bath. The concentrated samples were purified, if necessary, by passing through Florisil columns. Identification and quantification of pesticides were made by gas-liquid chromatography and were corroborated through the use of two or more unlike columns (USEPA, 1971).

Solids (dissolved)--Samples were brought to room temperature, and well-mixed aliquots were passed through Reeve Angel, type 934 AH filters with gentle suction. One hundred mL was transferred quantitatively to pre-weighed evaporating dishes. Samples were evaporated to dryness at 100° C in a water bath and placed in an oven at 180° C for 1½ to 2 hours. Evaporating dishes were weighed again after cooling in a desiccator (USEPA, 1974).

Solids (suspended)--Samples were brought to room temperature and mixed thoroughly. Using gentle suction, 50 mL of sample was filtered through Reeve Angel, type 934 AH filters in 25 mL tared Gooch crucibles. The filtered samples were dried in an oven at 104° C for one to two hours. Crucibles and filters were desiccated until cool and reweighed (USEPA, 1974).

Solids (total)--Data for total solids were obtained by summing the dissolved and suspended solids values.

Solids (volatile suspended)--The solids retained on the filter from the suspended solids analysis were ignited at 550° C in a muffle furnace to determine volatile suspended solids (USEPA, 1974).

Sulfate sulfur--Round one was analyzed for sulfate with a lead specific ion electrode. Samples were diluted 1:1 with methanol. These were titrated with lead perchlorate until the millivolt readings fell within a range established by a blank curve. The exact sulfate concentration was extrapolated from a standard curve plotted on Grans plotting paper (Orion IM, 1975d).

Due to the inability to duplicate sulfate results using other methods, the remaining rounds of sulfates were analyzed turbidimetrically by the barium sulfate method. While the solution was being stirred, conditioning reagent and barium chloride crystals were added. After exactly one minute, the barium sulfate turbidity was read at 420 nm on a spectrophotometer, and the sulfate concentration was calculated from a standard curve prepared from serially diluted standards of a 1,000 mg/L sodium sulfate stock solution (APHA, 1976).

## Methods for Analyses of Soils

### Laboratory Analyses--

Cation exchange capacity--Air-dried soil samples (<2 mm particle size) and 1 N ammonium acetate were shaken for several minutes and allowed to stand overnight. Sample extracts were filtered through perforated Coors crucibles containing Reeve Angel glass fiber filters using gentle suction. Soil leaching was done with 1 N ammonium acetate, adding small amounts at a time so that leaching took no less than one hour. This was followed by leaching with 95 percent ethanol in small amounts until the leachate gave a negative test for ammonia with Nessler's reagent. The soil was air-dried and weighed. Water was added, and ammonia was measured with an ammonia electrode by immersing into the sample and adding 10 N sodium hydroxide to raise the pH. Ammonia concentration was determined from a standard curve prepared from serially diluted standards of 1,000 mg/L ammonium chloride stock solution. No modifications were made for calcareous soils (Orion IM, 1975a; Busenberg, 1973; and Black, 1965).

Boron--Air-dried soil samples were refluxed with distilled water for 30 minutes. The soil-water suspension was separated by adding 1 N calcium chloride and centrifuging at 2,000 rpm for 10 minutes. The boron concentration of the supernatant was determined by the curcumin method (APHA, 1976, and Black, 1965).

Herbicides--Air-dried soil samples were mixed with water, sulfuric acid, and diethyl ether. After shaking for four hours, the extracts were filtered through anhydrous sodium sulfate. An aliquot of the ether extract was transferred to a separatory funnel and shaken with sodium hydroxide. The aqueous phase was transferred to another separatory funnel, the pH adjusted to 3, and extracted with ether. Mineral oil in hexane was added to the extract and evaporated carefully to 5 mL, employing a 50° C water bath and a Snyder column. The extract was further evaporated to 0.1 mL. The phenoxy acids were esterified using boron trifluoride in methanol, as described for herbicides in water (Woodham, 1971).

Metals (exchangeable and extractable)--Air-dried soil was pulverized by mortar and pestle to pass a 2 mm screen.

Aluminum was extracted with 1 N potassium chloride. The suspension was filtered immediately, and the solids were washed with 1 N potassium chloride (Ellis, 1975). Aluminum was analyzed by atomic absorption.

The ions K, Mg, and Na were exchanged with 1 N ammonium acetate by shaking for five minutes. Extracts were filtered through Whatman No. 40 filter paper and analyzed by atomic absorption (Ellis, 1975).

The metals Fe, Zn, Mn, Cu, Ni, Pb, Cr, and Co were extracted from soils by shaking for two hours with triethanolamine, calcium chloride, and carboxymethylimino bis-ethylenenitrilo-tetraacetic acid (DTPA) (10 mL per 4 g soil), followed by filtering through Whatman No. 42 filter paper (Ellis, 1975). The metals were analyzed by atomic absorption.

Metals (total)--Samples were prepared by digesting soil in teflon beakers with hydrofluoric acid and evaporating the liquid to dryness. This was followed by digesting with a 3:1 hydrochloric: nitric acid mixture (aqua regia) for five minutes and then redissolving any residue in 1:1 hydrochloric acid. Samples were filtered and analyzed by atomic absorption spectrophotometry.

Total mercury analyses were prepared by digesting soils with aqua regia for two minutes in a 95° C water bath, followed by a 5 percent potassium permanganate digestion for 30 minutes. Sodium chloride, hydroxylamine hydrochloride, and distilled water were mixed with the sample and stannous sulfate was added to vaporize the mercury through the absorption cell (USEPA, 1974).

Total arsenic and selenium analyses were prepared by refluxing the soil samples two times with nitric acid, followed by digestion with hydrogen peroxide and nitric acid. Nickel nitrate was added to the digested samples prior to analyses by atomic absorption, using the heated graphite atomizer and electrodeless discharge lamps.

Nitrogen (inorganic)--Because ammonia, nitrate, and nitrite nitrogen readily change form in soil, these parameters were summed to obtain inorganic nitrogen values. Ammonia, nitrate, and nitrite nitrogen were determined by the following methods.

Ammonia nitrogen was determined after extracting air-dried soil with 2 N potassium chloride by shaking on a rotary shaker for two hours. Samples were allowed to sit for 30 minutes before being analyzed for ammonia with an ammonia electrode. The probe was immersed in the sample, followed by the addition of sodium hydroxide to raise the pH. Ammonia concentration was determined from a standard curve prepared from serially diluted standards of a 1,000 mg/L ammonium chloride stock solution (Orion, IM, 1975a, and Black, 1965).

For the nitrate and nitrite nitrogen determination, potassium chloride (2 N) was used to extract the ammonia, nitrate, and nitrite from the air-dried soil by shaking together for one hour. The suspension was filtered through Whatman No. 4 filter paper. The pH was adjusted between 11 and 14 with 10 N sodium hydroxide. At least half the volume of the filtrate was evaporated by boiling, to drive off all ammonia nitrogen. After cooling and adjusting the filtrate to the original volume, concentrated sulfuric acid and Devarda's alloy were added. Samples were placed in a $70^{\circ}$ C water bath for two hours for reduction of nitrate and nitrite to ammonia. Ammonia concentrations of the solutions were measured with an ammonia electrode after addition of sodium hydroxide. Ammonia concentration was determined from a standard curve prepared from serially diluted standards of a 1,000 mg/L ammonium chloride stock solution (Orion IM, 1975b; Orion IM, 1976c; and Black, 1965).

Nitrogen (organic)--Air-dried soil was digested with concentrated sulfuric acid, potassium sulfate, cupric sulfate, and selenium. The solutions were evaporated for 30 minutes past the disappearance of sulfurous acid fumes. Samples were diluted, neutralized with sodium hydroxide, and analyzed with an ammonia electrode. Ammonia concentration was determined from a standard curve prepared from serially diluted standards of a 1,000 mg/L ammonium chloride stock solution (Orion IM, 1975a; Bremner, 1972; and Black, 1965).

Pesticides--Soil samples were air-dried, mixed with Celite, and Soxhlet extracted for 12 hours with hexane: acetone (41:59 v/v). The extracts were then shaken in a separatory funnel with a saturated sodium chloride solution and extracted with hexane. The extracts were washed twice with a saturated sodium chloride solution. The hexane phase was dried with anhydrous sodium sulfate. Unless further purification was necessary, the samples were ready for gas chromatographic analyses (Williams, 1968).

pH--The soil was air-dried and pulverized by mortar and pestle before samples were analyzed. Twenty-five mL of distilled water per gram of soil was added and the mixture stirred. The pH was measured while the sample was mixing (Black, 1965).

Phosphorus (available)--Samples of air-dried soil were extracted with 0.03 N ammonium fluoride and 0.025 N hydrochloric acid by shaking for one minute. The extract was filtered through Whatman No. 42 filter paper and the pH adjusted to 7.0 ± 0.2 with sodium hydroxide. Color reagent (mixture of antimony potassium tartrate, ammonium molybdate, and ascorbic acid) was added, and the absorbance was read at 640 nm with a spectrophotometer (APHA, 1976, and Black, 1965).

Phosphorus (total)--Air-dried soil samples were digested with 6 percent perchloric acid in a flask. Samples were boiled until the dark color due to organic matter disappeared. An aliquot was adjusted to pH 7.0 ± 0.2 with sodium hydroxide, followed by the addition of color reagent. After color development, absorbance was measured on a spectrophotometer at 640 nm (APHA, 1976, and Black, 1965).

Sulfur (total)--Sulfate sulfur and organic sulfur were combined to obtain total sulfur values.

For the determination of sulfate sulfur, monobasic calcium phosphate was added to air-dried soil samples and shaken for 12 hours, followed by filtering through a Gooch crucible fitted with a glass fiber filter. An aliquot of filtrate, gum acacia solution, and hydrochloric acid was mixed with barium chloride crystals. Absorbance was measured at 420 nm on a spectrophotometer. The concentration of sulfur in the samples was determined from a standard curve prepared from serially diluted standards of a stock sulfate solution (Black, 1965).

The residue in the Gooch crucible from the sulfate sulfur determination was used for organic sulfur analyses. After drying at 103° C, sodium bicarbonate was mixed with the soil and added uniformly as a surface layer. After ignition at 500° C for three hours the sample was extracted and analyzed as described for sulfate sulfur (Black, 1965).

## Methodology Problems and Modifications

As indicated previously, certain difficulties in analyses were experienced in using the standard methods. The following sections discuss the problems encountered in the water and soil analyses and indicate the modifications that were employed in an attempt to obtain measurements of the parameters involved in the study. Table 7 summarized the modifications for field methods for each of the sampling rounds during the study.

The problems and modifications are mentioned for two reasons. First, for time-critical parameters, it may be the explanation for missing data for certain samples. If the method was known to be faulty, the data were deleted from the data tabulation shown in Appendix B. Second, certain analytical procedures were modified to obtain accurate results for the types of samples encountered in this study. These modifications are reported for the benefit of future investigators for similar type studies. Also, it was deemed valuable to report those cases when certain new analytical tools did not conform to the manufacturer's claims.

### Water Analyses--

Calcium--Initial review of calcium data indicated low values were being generated. Spiked samples indicated low recoveries. Therefore, all samples were repeated and were run by the method of standard addition. Excellent recoveries were obtained; therefore, all calcium data are valid.

Chemical oxygen demand--Results from some of the early field samples stimulated questions concerning the procedure being used. Extensive spiking and duplication of samples showed no methodology problems and no reason for the anomalous data.

Chloride--The initial problem was a faulty electrode. Later problems involved matrix interferences. The probe method was replaced by mercuric nitrate titrations as listed in the EPA methods manual (USEPA, 1974).

Metals--Data from several metals appeared anomalous at some time during the analyses. A malfunctioning atomic absorption (AA) was initially a problem. Failures included several faulty hollow cathode lamps, a faulty printed circuit board in the photomultiplier, an out-of-tolerance nebulizer, and numerous graphite rods (cuvettes) that had been manufactured without meeting specifications. Analyses in question were repeated, using an operational instrument. All metal analyses reported are considered valid data.

Nitrate nitrogen--The nitrate probe was used according to the manufacturer's directions with success for some samples, but problems were encountered with other samples. Discussions with the manufacturer resulted in new filling solutions for the probe and different ionic strength adjuster solutions to aid in reducing interferences. Some faulty probes were also discovered during the analyses. Although the probe method was abandoned during round two sampling, nitrate values obtained by the probe were comparable to Cd reduction method values, and data were thus considered valid.

Organic nitrogen--The EPA method was modified initially by using the ammonia probe instead of distilling the ammonia and titrating. It was discovered later that the temperature of the solutions measured with the electrode varied markedly, depending on the amount of acid in the solutions. This temperature variation affected the probe adversely; thus, it was found necessary to partially neutralize samples to about pH 5, cool to room temperature, then add the remainder of the base and measure the ammonia with the probe. Several items concealed this problem initially. Three electrode failures were experienced, and thus questionable data were attributed to this. It was also discovered that mercuric ions in the digesting reagent were not releasing the ammonium during analyses.

Sulfate sulfur--The sulfate (lead) probe was used according to the manufacturer's directions with little success at the sampling sites, although initial tests proved the method satisfactory. Discussions with the manufacturer resulted in numerous changes in the solutions used during analyses. The probe was later found to be faulty as well. All first round sulfate analyses were discarded from the data base. The probe was abandoned, and only turbidimetric measurements were used for the remaining samples for the final three rounds.

Soil Analyses--

Inorganic nitrogen--Nitrate plus nitrite nitrogen was determined initially according to the ASOA method, with the exception that steam distillation of ammonia was replaced by the use of the ammonia probe. Spiked samples indicated that reduction of nitrate and nitrite was limited and that the method was underestimating the concentrations of nitrate and nitrite nitrogen. After much experimentation, it was discovered that the Devarda alloy would not reduce $NO_3$ and $NO_2$ to $NH_4$ without the addition of a proton donor. Satisfactory results were obtained by adding small amounts (<1 mL) of concentrated $H_2SO_4$.

Organic nitrogen (total)--The method as described by Bremner and Tabatabai (1972) was followed initially. The temperature interference described for the organic nitrogen procedure for water samples was initially a problem for soil samples. Partial neutralization followed by cooling solved the difficulty of obtaining accurate results.

## DATA EVALUATION PLAN

General background data about the site including geology, hydrogeology, soils, climate, and other relevant information have previously been presented.

Data collected at the field site from wells, effluent samples, and soils were transmitted to the laboratory for collation and computer tabulation. Additional analytical procedures at the laboratory provided data on many parameters, which were integrated with field data. Appendix B provides complete data tables for all parameters that had reliable, internally consistent results. In some instances columns of data were combined, such as ammonium and nitrate-nitrite nitrogen, if analytical procedures indicated that individual parameters might overlap.

In the Results and Discussion section the critical resource values of water and soils are compared for the test and control sites.

The evaluation of the results of water analyses is presented in three parts: effluent, groundwater, and surface water. In each part the results are discussed in relation to such site characteristics as hydrology, renovation performance of the soil, or quality of the groundwater. In addition, some projections are attempted for long-term loadings of critical parameters contained in the wastewater.

In analyzing the groundwater data, constituent concentrations are traced along the paths coinciding with groundwater movement beneath and downgradient from the three basins. Figures 10, 11, and 12 depict the sample wells and cross sections traced in analyzing the groundwater for Basins I, II, and III, respectively.

Wells 42060, 42080, 42090, 42100, and 42110 are used to analyze the groundwater beneath Basin I (Figure 10). In a statistical analysis the mean parameter concentrations for the groundwater beneath Basin I are compared to downgradient wells 42300, 42310, and 42350. Also in a statistical analysis, mean parameter concentrations for a group of downgradient wells 42270, 42280, and 42290, which are close to Basin I, are compared to wells 42300, 42310, and 42350, which are further downgradient. In addition, in a more detailed analysis the constituent concentrations in the groundwater beneath Basin I are compared to downgradient wells 42280, 42290, 42310, and 42350.

Wells 42030, 42040, 42170, 42180, 42190, 42200, and 42210 are used to analyze the constituent concentrations in the groundwater beneath Basin II

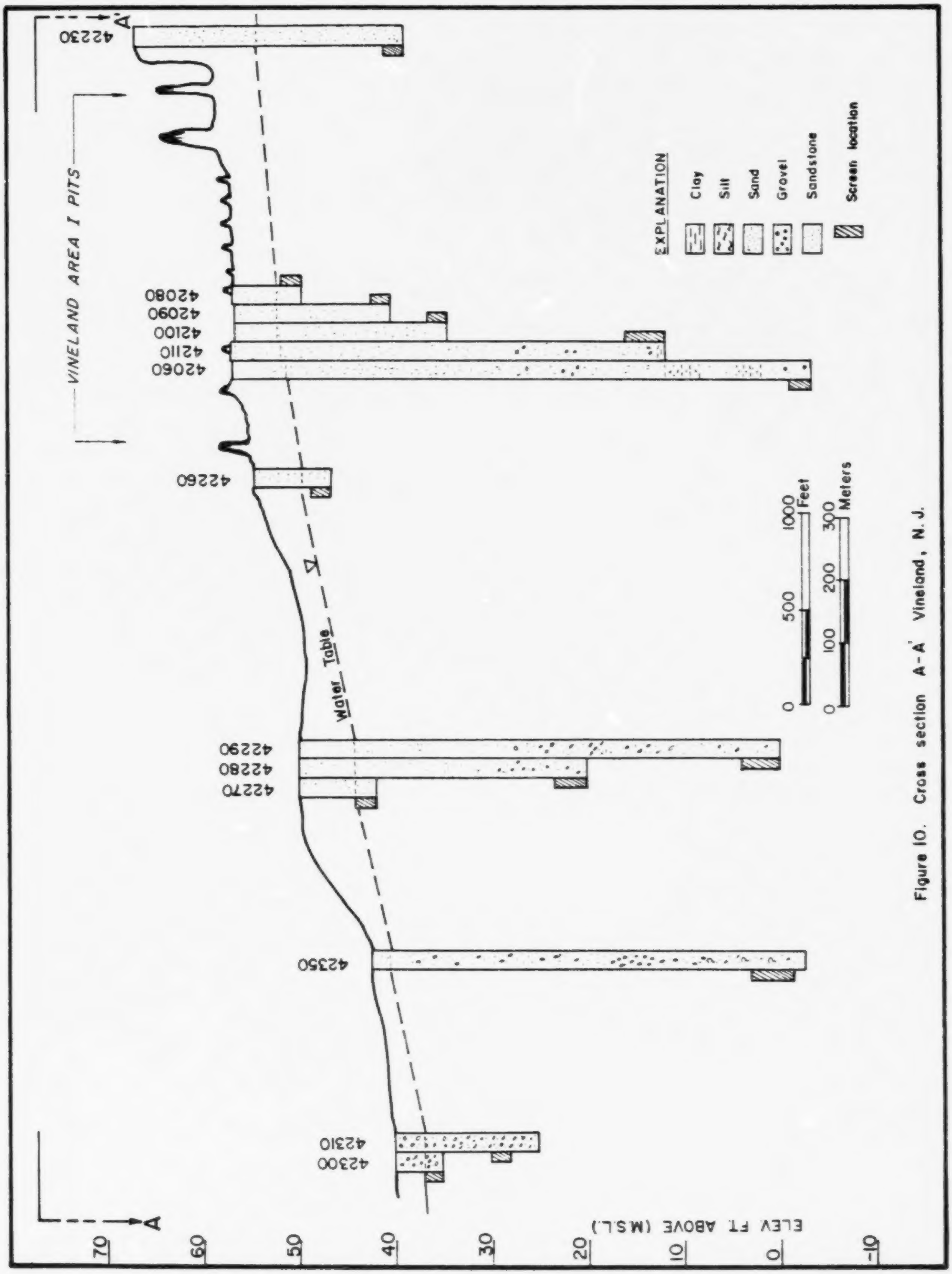

A
A'
VINELAND AREA I PITS
ELEV FT ABOVE (M.S.L.)
70
60
50
40
30
20
10
0
-10
42300
42310
42350
42270
42280
42290
42260
42060
42110
42100
42090
42080
42230
Water Table
EXPLANATION
Clay
Silt
Sand
Gravel
Sandstone
Screen location
0
500
1000
Feet
0
100
200
300
Meters

Figure 10. Cross section A-A' Vineland, N.J.

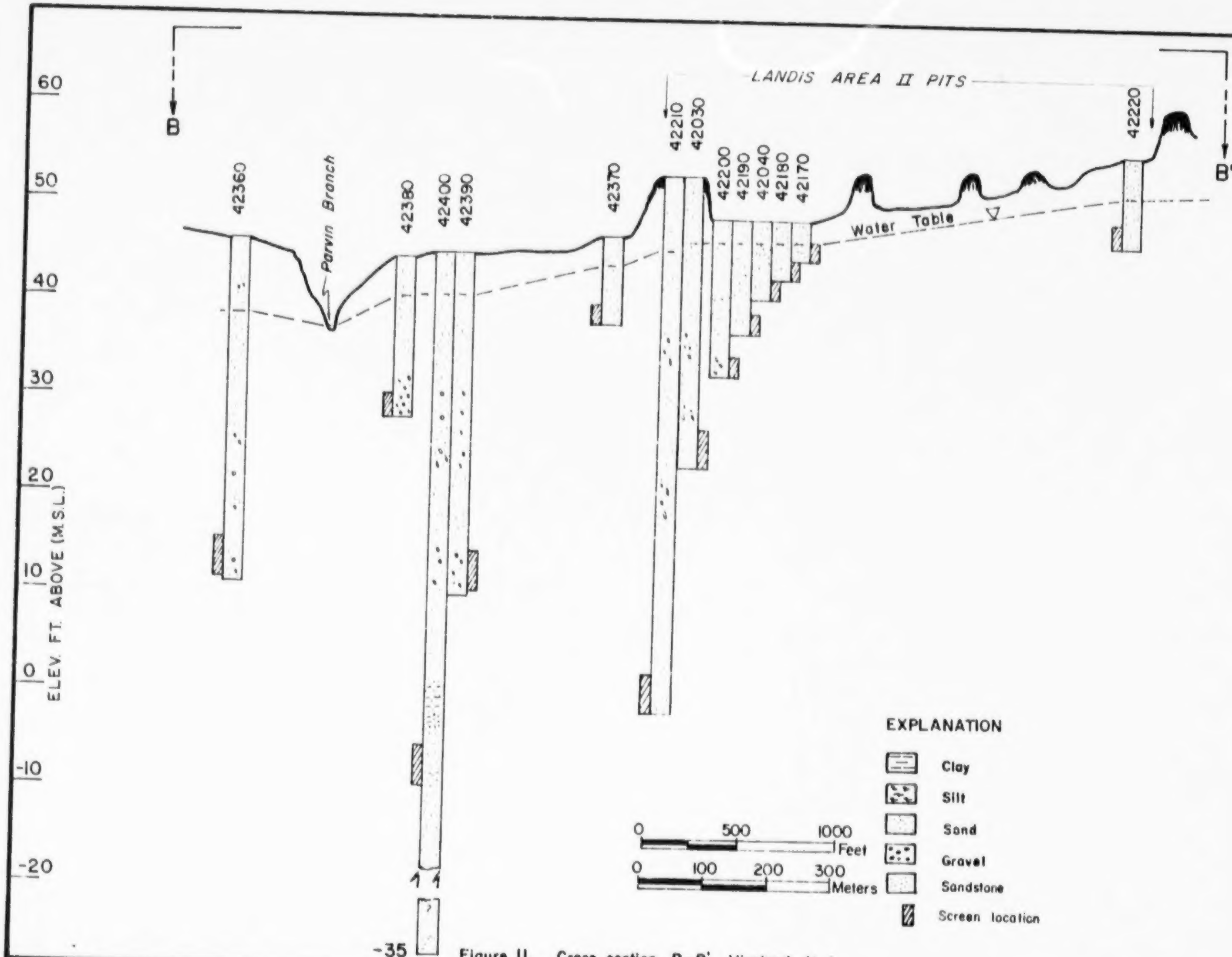

B
B'
LANDIS AREA II PITS
60
50
40
30
20
10
0
-10
-20
-35
ELEV. FT. ABOVE (M.S.L.)
42360
Parvin Branch
42380
42400
42390
42370
42210
42030
42200
42190
42040
42180
42170
42220
Water Table
0
500
1000
Feet
0
100
200
300
Meters
EXPLANATION
Clay
Silt
Sand
Gravel
Sandstone
Screen location

Figure 11. Cross section B-B' Vineland, N. J.

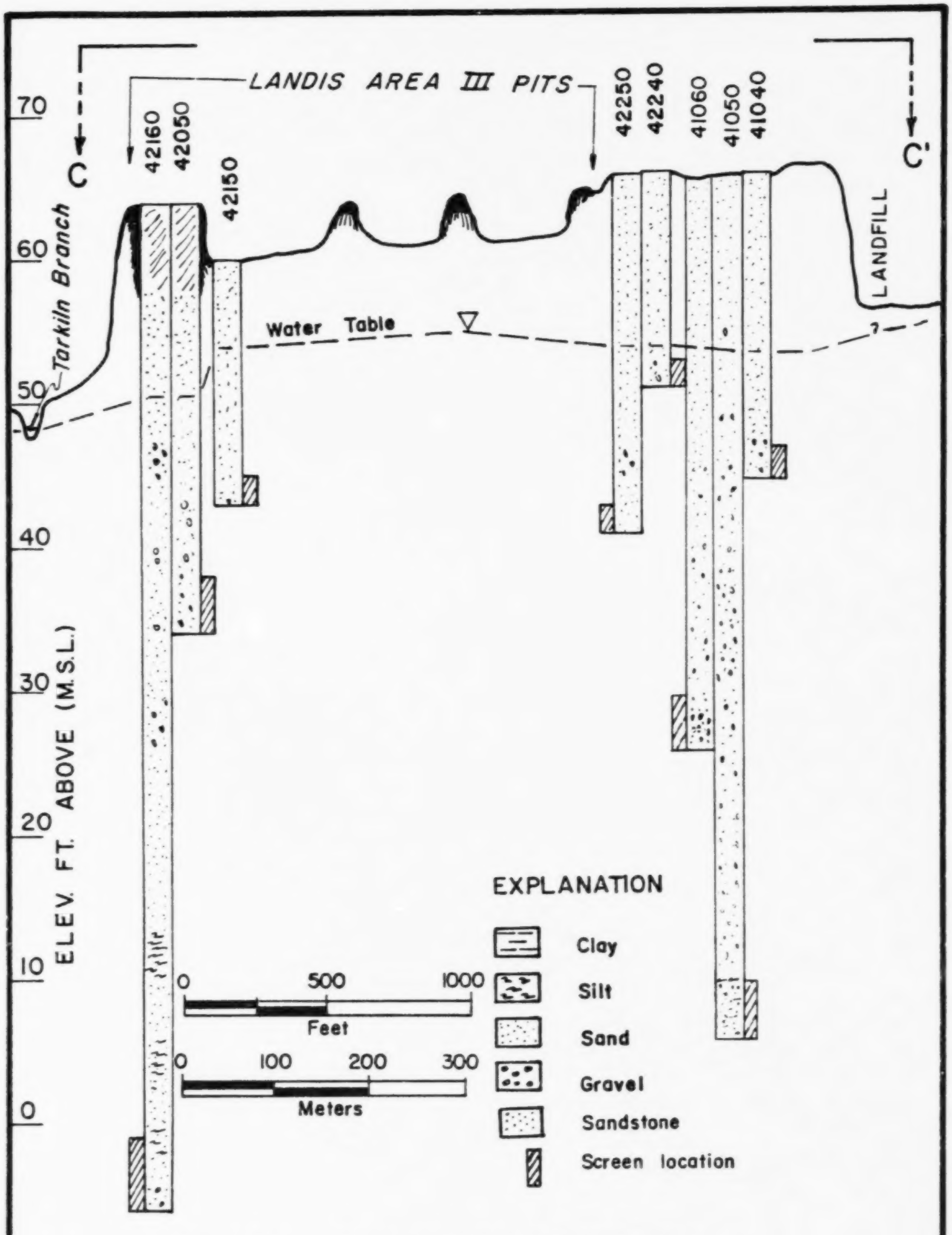

C
C'
LANDIS AREA III PITS
42160
42050
42150
42250
42240
41060
41050
41040
Tarkiln Branch
LANDFILL
Water Table
?
ELEV. FT. ABOVE (M.S.L.)
70
60
50
40
30
20
10
0
0
500
1000
Feet
0
100
200
300
Meters
EXPLANATION
Clay
Silt
Sand
Gravel
Sandstone
Screen location

Figure 12. Cross section C-C' Vineland, N. J.

(Figure 11). Mean parameter concentrations for groundwater beneath Basin II are also compared to downgradient wells 42380, 42390, and 42400.

Wells 42050, 42150, and 42160 are used to analyze the constituent concentrations in the groundwater beneath Basin III (Figure 12). Mean parameter concentrations for groundwater beneath Basin III are compared to the groundwater of wells 41040, 41050, and 41060, which is representative of underflow from the landfill.

For soils the results that merited discussion include nitrogen, phosphorus, zinc, copper, iron, manganese, potassium, and magnesium. Other parameters found to be significantly greater in the test site soils at the depth 0-30 cm are listed. Although values were obtained for many other parameters the differences between control and test sites were generally within the range of variability expected for any one soil site.

Finally, the movement and survival of viruses and fecal and total coliform bacteria were investigated. Discussion of the methods used and the results obtained for these parameters follows in the sections on water and soils.

# SECTION 7

# RESULTS AND DISCUSSION

Samples collected in the field were identified by a code number that was used on all data tables and graphs as well as in the narrative sections where individual sample results are discussed. The wells at the Vineland site were coded according to a five-digit number. The first digit (4) referred to the Vineland site; the second digit indicated whether the sample was from a control (1) or test (2) site; the third and fourth digits indicated the sample well number (01 to 40); the fifth digit was always 0.

The well water samples were numbered using a six-digit code. The first four digits indicated the well and location, while the last two digits indicated the sampling round--first digit: 4 - Vineland; second digit: 1 - control site wells, 2 - test site wells; third and fourth digits: 01 to 40 - well numbers, 44 to 52 - surface water, 55 - Landis treatment plant effluent, 56 - Vineland treatment plant effluent, 60 - municipal water; fifth and sixth digits: 01 - sample collected first round (August, 1976), 02 - sample collected second round (December, 1976), 03 - sample collected third round (March, 1977), 04 - sample collected fourth round (May, 1977).

Drive core soil samples were numbered using a five-digit code--first digit: 4 - Vineland; second digit: 1 - control site, 2 - test site; third digit: 1 - Vineland Basin I, 2 - Landis Basin II, 3 - Landis Basin III; fourth digit: 1 - first sampling round (August, 1976), 3 - third sampling round (March, 1977); fifth digit: 1 - sample depth (0-31 cm), 5 - sample depth (95-105 cm), 6 - sample depth (295-305 cm).

## WATER

### Effluent Constituents

The Vineland and Landis treatment plants produce effluents for infiltration that are typical of primary treatment. Laboratory analyses of the effluents were run in August and December, 1976, and in March and May, 1977, for the purpose of examining seasonal effects. The results are summarized in Table 8 for Vineland effluent sample numbers 425601 through 425604 and for Landis effluent sample numbers 425501 through 425504.

Also presented in Table 8 is a summary of component data for the Vineland municipal water supply. Samples were taken for analysis in December, 1976, and March, 1977, and are designated sample numbers 416002 and 416003.

TABLE 8. SUMMARY OF CONSTITUENT CONCENTRATIONS IN VINELAND AND LANDIS TREATMENT PLANT EFFLUENTS AND VINELAND MUNICIPAL WATER SUPPLY

| Parameter (mg/L unless noted) | Treatment Plant Effluents | | | | Vineland Municipal Water Supply | |
|---|---|---|---|---|---|---|
| | Vineland | | Landis | | | |
| | Range | Mean | Range | Mean | Range | Mean |
| Dissolved Oxygen | 0.4-2.6 | 1.5 | <0.1-3.3 | 1.8 | 6.2-7.5 | 6.9 |
| pH (units) | 5.6-7.0 | 6.5 | 5.5-7.5 | 6.8 | 7.3-8.9 | 8.1 |
| Conductivity (µmhos/cm) | 432-848 | 548 | 425-1001 | 602 | 66 | 66 |
| Total Alkalinity | 92-136 | 115 | 88-149 | 130 | 24-28 | 26 |
| Dissolved Solids | 163-268 | 214 | 186-514 | 301 | 37-63 | 50 |
| Suspended Solids | 19-56 | 43 | 34-54 | 41 | 3 | 3 |
| Total Solids | 182-326 | 258 | 240-553 | 342 | 66 | 66 |
| Volatile Suspended Solids | 9-45 | 27 | 11-44 | 29 | | |
| Biochemical Oxygen Demand | 90-215 | 154 | 136-173 | 149 | 2 | 2 |
| Chemical Oxygen Demand | 237-472 | 372 | 272-315 | 287 | 3 | 3 |
| Chloride | 19-135 | 57 | 19-179 | 77 | 1-4 | 3 |
| Sulfide-S | <0.1 | <0.1 | <0.1 | <0.1 | | |
| Total Coliform (#/100mL) | 400-TNTC[c] | TNTC | TNTC | TNTC | | |
| Fecal Coliform (#/100mL) | 0-TNTC | TNTC | 0-TNTC | TNTC | | |
| Total Organic C | 56-153 | 108 | 56-116 | 82 | <1 | <1 |
| Dissolved Organic C | 57-124 | 85 | 42.9-55.6 | 48 | <0.5 | <0.5 |
| Total Organic N | 4.2-35.8 | 23.1 | 0.66-34.8 | 18.5 | 0.9 | 0.9 |
| Soluble Organic N | 3.0-27.6 | 16.8 | 15.9-25.4 | 21.1 | <0.1-0.4 | <0.3 |
| Ammonium-N | 5.0-25.1 | 17.2 | 13.8-23.7 | 19.0 | 0.3 | 0.3 |
| Nitrate-N | <0.1-0.2 | 0.1 | <0.1-3.7 | 1.3 | 1.1-2.5 | 1.8 |
| Total Phosphorus | 5.8-15.5 | 9.3 | 6.5-12.5 | 9.0 | -- | -- |
| Soluble Phosphorus | 4.5-6.9 | 5.7 | 5.4-7.2 | 6.3 | 0.2-0.4 | 0.3 |
| Soluble Orthophosphate | 3.7-6.2 | 4.8 | 3.5-5.9 | 4.8 | 0.04-0.07 | 0.06 |
| Sulfate | 8-26 | 14 | 17-32 | 24 | 4-5 | 5 |
| Aluminum | 0.3[b]-0.8 | 0.6 | 0.3[b]-0.9 | 0.6 | 0.4-0.8 | 0.6 |
| Arsenic (µg/L) | 5[b]-20[b] | <5 | 5-20[b] | <5 | 10[b]-20[b] | <10 |
| Boron (µg/L) | 34-460 | 311 | 350-642 | 534 | 31-248 | 140 |
| Cadmium (µg/L) | 20[b]-50[b] | <20 | 20[b]-50[b] | <20 | 20[b]-50[b] | <20 |
| Calcium | 10-13 | 12 | 8-13 | 11 | 4-6 | 5 |
| Cobalt (µg/L) | 50[b]-100[b] | <50 | 50[b]-100[b] | <50 | 50[b]-100[b] | <50 |
| Chromium (µg/L) | 20[b]-26 | <20 | 20[b]-50[b] | <20 | 20[b]-50[b] | <20 |
| Copper (µg/L) | 47-72 | 58 | 54-96 | 77 | 20[b]-50[b] | <20 |
| Iron | 1.0-2.4 | 1.5 | 0.6-2.9 | 1.2 | 0.1[b]-0.2[b] | <0.1 |
| Lead (µg/L) | 100[b]-200[b] | <100 | 100[b]-200[b] | <100 | 100[b]-200[b] | <100 |
| Magnesium | 3-6 | 4 | 3-5 | 4 | 1-2 | 1.4 |
| Manganese | 0.05[b]-0.09 | <0.05 | 0.03-0.10 | 0.06 | 0.05[b] | <0.05 |
| Mercury (µg/L) | 0.5[b]-<1.0[b] | <1.0 | 0.5[b]-1.0[b] | <1.0 | 0.5[b]-1.0[b] | <1.0 |
| Nickel (µg/L) | 50[b]-100[b] | <100 | 50[b]-100[b] | <100 | 50[b]-100[b] | <100 |
| Potassium | 9.8-26.3 | 14.5 | 9.3-11.3 | 10.4 | 1.6 | 1.6 |
| Sodium | 38-117 | 60 | 30-145 | 75 | 3-4 | 3.4 |
| Zinc (µg/L) | 111-146 | 127 | 72-207 | 121 | 20[b]-29 | <20 |
| Selenium (µg/L) | 10[b] | <10 | 10[b] | <10 | 10[b] | <10 |
| Endrin (ng/L) | 0.03[b] | <0.03 | 0.03[b] | <0.03 | 0.03[b] | <0.03 |
| Lindane (ng/L) | 120-10,300 | 2,830 | 0.5-4,510 | 1,227 | <1.1-4.2 | 2.4 |
| Methoxyclor (ng/L) | 0.01[b] | <0.01 | 0.01[b] | <0.01 | 0.01[b] | <0.01 |
| Toxaphene (ng/L) | 0.1[b] | <0.1 | 0.1[b] | <0.1 | 0.1[b] | <0.1 |
| 2,4-D (ng/L) | 0.5-54[b] | 9.5 | 2.0[b]-54[b] | 10.5 | 0.1[b]-2.1[b] | <1.1 |
| 2,4,5 TP Silvex (ng/L) | 6.8-126 | 72.0 | 35.0-131.0 | 72 | 49.0-60.0 | 55.0 |

[b] Concentrations below detection limit indicated.
[c] At least on sample analyzed too numerous to count.

Effluent five-day biochemical oxygen demand ($BOD_5$) concentrations were comparable for the two effluents and were typically in the range of 90 to 215 mg/L with an average of 154 mg/L for the Vineland plant and between 136 and 173 mg/L with an average of 149 mg/L for the Landis plant. Suspended solids (SS) concentrations ranged from 19 to 56 mg/L with an average of 43 mg/L at Vineland and from 34 to 54 mg/L at Landis with an average of 41 mg/L. The Landis plant is reported to have an approximate fifty percent contribution from food processing industries that apparently does not significantly affect $BOD_5$ or SS concentrations.

The chemical oxygen demand (COD) concentrations were in the ranges of 237 to 472 and 272 to 315 mg/L with averages of 372 and 287 mg/L for Vineland and Landis, respectively.

Ammonium nitrogen concentrations for the two effluents were also comparable with averages of 17.2 and 19 mg/L for Vineland and Landis, respectively. Organic nitrogen average concentrations were 23.1 mg/L for Vineland and 18.5 mg/L for Landis. The average nitrate nitrogen concentration was 0.1 mg/L for Vineland and 1.3 mg/L for Landis. Average total nitrogen concentration at Landis was 38.8 mg/L as contrasted with 40.4 mg/L at Vineland. This range of total nitrogen concentration is customary for primary plants.

Average total phosphorus concentrations were 9.3 and 9.0 mg/L for the Vineland and Landis plants, respectively. Average soluble phosphorus concentrations were 5.7 and 6.3 mg/L, and the average soluble orthophosphate concentration was 4.8 mg/L for both effluents for the Vineland and Landis plants, respectively.

Sodium, boron, potassium, sulfate, chloride, and dissolved solids showed the marked increase in concentration anticipated by a cycle of municipal water use. For example, the Vineland municipal supply had a measured chloride concentration in the range of 1 to 4 mg/L while the effluents had average chloride concentrations of 57 to 77 mg/L. This was normal for a municipal primary effluent, as was the increase in dissolved solids from an average 50 mg/L in the municipal supply to average concentrations of 214 to 301 mg/L in the treatment plant effluents.

Among the indicator pesticides and herbicides, lindane was the only parameter showing significantly higher concentrations in the effluent as contrasted with the municipal supply. Lindane concentrations ranged from 120 to 10,300 and from 0.5 to 4,510 ng/L and averaged 2,860 and 1,227 ng/L for Vineland and Landis effluents, respectively. This compares favorably with the National Interim Primary Drinking Water Regulations maximum contaminant level for lindane of 4,000 ng/L.

Overall observations that could be made concerning the Vineland and Landis treatment plant effluents were: (1) All parameters were typical of primary effluent with increased concentrations, when compared with the Vineland municipal supply water, of $BOD_5$, SS, COD, nitrogen, phosphorus, sodium, boron, potassium, sulfate, chloride, and dissolved solids; and (2) lindane was identified at above-background levels and with average concentrations of 1,227 to 2,860 ng/L for Landis and Vineland effluents, respectively.

A statistical comparison was made of mean concentrations of various parameters for the Vineland effluent applied to Basin I versus the control groundwater wells 41010, 41020, and 41030 using the method of pooled variances at the 0.05 level of significance. For purposes of the evaluation, analytical data determined below the limit of detection were arbitrarily input at one-half the detection limit value to obtain a mean value. For this reason, mean values for some parameters were reported lower than the limit of detection values. The results of the analysis are shown in Table 9. The analysis showed significant differences in mean concentrations for 20 parameters of 48 parameters analyzed. Only 42 parameters are shown in the following tables. The six parameters, suspended solids, total solids, volatile suspended solids, total organic carbon, total organic nitrogen, and total phosphorus, were not included because the comparisons were explained by the data from dissolved solids, dissolved organic carbon, soluble organic nitrogen, soluble phosphorus, and soluble orthophosphate. For those parameters with significant differences, 19 had mean concentrations that were significantly greater in the treatment plant effluent than in the control groundwater. These parameters are pH, conductivity, total alkalinity, dissolved solids, $BOD_5$, COD, chloride, dissolved organic carbon, soluble organic nitrogen, ammonia, soluble phosphorus, soluble orthophosphate, boron, calcium, magnesium, potassium, sodium, zinc, and lindane. Mean dissolved oxygen concentration was significantly greater in the control groundwater than in the treatment plant effluent. As shown in Table 9, concentrations for many of the metals were consistently below detection limits for both the treatment plant effluent and the control groundwater. In addition, for both total and fecal coliform, at least one sample of the treatment plant effluent yielded results too numerous to count (TNTC) and prevented comparing the means for the two parameters statistically to the control groundwater. For the remaining parameters, no significant differences were found.

In another statistical comparison, the mean parameter concentrations of the Landis effluent applied to Basins II and III were compared to the control groundwater wells 41010, 41020, and 41030. Significant differences were found to exist for 20 parameters (Table 9). As in the previous comparison, dissolved oxygen was the only parameter with a mean concentration greater in the control groundwater than in the treatment plant effluent. Except for sulfate replacing lindane, the remaining same 18 parameters had means which were significantly greater in the treatment plant effluent than in the control groundwater. Mean concentrations for most metals were below detection limits. Also, at least one sample of the Landis effluent yielded total and fecal coliform counts that were too numerous to count. There were no differences for the remaining parameters at the 0.05 level of significance.

## Municipal Supply Constituents

The Vineland municipal water supply is from a deep aquifer underlying the Vineland area, which is separated from the sand layers used for the Vineland and Landis infiltration ponds. Knowledge of water supply constituents was necessary to provide background concentrations that could be compared with concentrations in the treatment plant effluents. The individual

### TABLE 9. MEAN CONCENTRATIONS OF PARAMETERS IN CONTROL SITE GROUNDWATER AND THE APPLIED VINELAND AND LANDIS EFFLUENTS

| Parameter | Means (mg/L unless noted) | | |
|---|---|---|---|
| | Control | Vineland | Landis |
| Dissolved Oxygen | 8.8 | 1.5$^a$ | 1.8$^a$ |
| pH (units) | 5.2 | 6.5$^a$ | 6.8$^a$ |
| Conductivity (μmhos/cm) | 64 | 548$^a$ | 602$^a$ |
| Total Alkalinity | 7 | 115$^a$ | 130$^a$ |
| Dissolved Solids | 40 | 214$^a$ | 301$^a$ |
| Biochemical Oxygen Demand | 1.1 | 154$^a$ | 149$^a$ |
| Chemical Oxygen Demand | 7 | 372$^a$ | 287$^a$ |
| Chloride | 4 | 57$^a$ | 77$^a$ |
| Sulfide-S | 0.1$^b$ | 0.1$^b$ | 0.1$^b$ |
| Total Coliform (#/100 mL) | 51 | TNTC$^c$ | TNTC |
| Fecal Coliform (#/100 mL) | 0 | TNTC | TNTC |
| Dissolved Organic C | 0.8 | 85$^a$ | 48$^a$ |
| Soluble Organic N | 1.8 | 16.8$^a$ | 21.1$^a$ |
| Ammonium-N | 0.1 | 17.2$^a$ | 19.0$^a$ |
| Nitrate-N | 1.0 | 0.1 | 1.3 |
| Soluble Phosphorus | 0.08 | 5.67$^a$ | 6.32$^a$ |
| Soluble Orthophosphate | 0.03 | 4.78$^a$ | 4.78$^a$ |
| Sulfate | 9 | 14 | 24$^a$ |
| Aluminum | 1.8 | 0.5 | 0.5$^b$ |
| Arsenic (μg/L) | 6 | 6 | 8 |
| Boron (μg/L) | 113 | 311$^a$ | 534$^a$ |
| Cadmium (μg/L) | 20$^b$ | 20$^b$ | 20$^b$ |
| Calcium | 3 | 12$^a$ | 11$^a$ |
| Cobalt (μg/L) | 50$^b$ | 50$^b$ | 50$^b$ |
| Chromium (μg/L) | 20$^b$ | 20$^b$ | 20$^b$ |
| Copper (μg/L) | 20$^b$ | 58 | 77 |
| Iron | 1.6 | 1.5 | 1.2 |
| Lead (μg/L) | 100$^b$ | 100$^b$ | 100$^b$ |
| Magnesium | 1 | 4$^a$ | 4$^a$ |
| Manganese | 0.11 | 0.05$^b$ | 0.06 |
| Mercury (μg/L) | 1$^b$ | 1$^b$ | 1$^b$ |
| Nickel (μg/L) | 100$^b$ | 100$^b$ | 100$^b$ |
| Potassium | 1.2 | 14.5$^a$ | 10.4$^a$ |
| Sodium | 2 | 60$^a$ | 75$^a$ |
| Zinc (μg/L) | 43 | 127$^a$ | 121$^a$ |
| Selenium (μg/L) | 10$^b$ | 10$^b$ | 10$^b$ |
| Endrin (ng/L) | 0.03$^b$ | 0.03$^b$ | 0.03$^b$ |
| Lindane (ng/L) | 21.3 | 2830$^a$ | 1227 |
| Methoxychlor (ng/L) | 0.01$^b$ | 0.01$^b$ | 0.01$^b$ |
| Toxaphene (ng/L) | 0.1$^b$ | 0.1$^b$ | 0.1$^b$ |
| 2,4-D (ng/L) | 10.4 | 9.5 | 10.5 |
| 2,4,5 TP Silvex (ng/L) | 185 | 72 | 72 |

[a] Test and control sites are significantly different at the 0.05 level.
[b] Average concentrations below detection limit indicated.
[c] TNTC - At least one sample too numerous to count.

constituent ranges and average concentrations tabulated in Table 8 have been discussed when relevant in the foregoing sections relating to treatment plant effluents.

## Groundwater

Primary effluent from the Vineland and Landis treatment systems is transmitted to the groundwater via a system of infiltration basins. The soils in the Vineland area consist largely of sand and other permeable subsoil particulates. The primary effluent derives treatment in the process of percolation and contact with these permeable strata.

Infiltration Basin I, which serves the Borough of Vineland, has been functioning for approximately 50 years, largely on a basis of continuous infiltration with little or no rest periods. The Landis Sewerage Authority has two infiltration basins, the older of which (II) had been operating for approximately 30 years in a continuous mode until 1974. Since 1974 the older Landis infiltration basin has been alternately flooded and dried, thus permitting reestablishment of aerobic soil conditions. The newer Landis infiltration basin (III) was put into operation in 1974 and has been in an intermittent flooding and drying mode since inception. The relative locations of the three infiltration basins are depicted in Figure 4 (page 13). The purpose of this report is to examine the degree of treatment provided by the three infiltration basins, including any effect due to the age of the infiltration system.

A complicating factor in the analysis of groundwater quality as related to the infiltrating flows from the three infiltration basins is the presence of a landfill site directly north of Basin III.

As previously discussed, the predominant direction of groundwater flow in the vicinity of the infiltration basins is southwesterly as indicated on Figure 4. Thus, contributions to groundwater from the landfill site can be expected to contribute to the two Landis basins (II and III) and possibly to the Vineland basin (I) as well.

The Vineland basin is 9.7 hectares (24 acres) in area and, as of 1974, received approximately 35 L/s (0.8 Mgal/d) for an average infiltration rate of 11 m/yr (36 ft/yr). The Landis basins comprise 26.3 hectares (65 acres) in area and, as of 1974, received approximately 180 L/s (4.1 Mgal/d) for an average infiltration rate of 21 m/yr (70 ft/yr). The projected rate of flow of the underlying groundwater is 1 to 2.5 m/day (3.5 to 8 ft/day).

The saturated zone beneath the bottom of the infiltration basins was nominally 1.4 m (4.5 ft) at Basin I, 0.8 m (2.7 ft) at Basin II, and 3.7 m (12 ft) at Basin III.

The control site groundwater monitoring area was established to the north of Basin I in soils that were similar to those at the treatment sites. Groundwater contributions to the control site are believed to be the result of infiltration by direct precipitation. The saturated zone in the soils underlying the control monitoring area is 3.7 m (12 ft) below ground level

(Table 6).

Reference to Figure 4 indicated that the groundwater under the infiltration site is mounded and that the mounding decreases with distance along the direction of groundwater travel. Perceptible mounding continues, however, to the southwest edge of the area monitored for this study. The groundwater flow net is complicated at the eastern edge of the monitored area by the close proximity of the Tarkiln and Parvin branches, streams tributary to the Maurice River. The groundwater contours indicate that the groundwater is discharging to the surface water at these streams. This is corroborated by analysis of the constituents within the river water and is discussed in a subsequent section of this report.

As a result of the mounding and the river influences, the groundwater contours indicate that there are flow components locally induced by the infiltration basins that travel in both westerly and easterly directions.

With the foregoing as a review of factors affecting groundwater quantity and quality, it is now appropriate to begin the discussion of groundwater quality parameters.

Monitoring wells were installed at the treatment and control areas (Figure 13). Test site wells are designated 42010 through 42400. Upgradient (control) wells are designated 41010, 41020, and 41030. Wells 41040, 41050, 41060, and 41070 are downgradient from the landfill and intended to monitor the effect of the landfill on the groundwater tributary to the infiltration basins.

Groundwater samples were taken from these wells at four times over a year, August and December of 1976, and March and May of 1977. Samples were analyzed for a number of water quality parameters, many of which are discussed in this section of the report.

### Statistical Comparisons of Groundwater Data

Using the sample data, various comparisons of parameter mean concentrations in the test groundwater and control groundwater were made with statistical techniques. In general, a comparison consisted of defining the regions of interest, computing sample parameter means for the regions of interest, and then testing for the existence of significant differences in the means at the 0.05 level using the method of pooled variances. As mentioned earlier, analytical data determined below the limit of detection was arbitrarily input at one-half the detection limit to obtain a mean value.

In the previously discussed comparisons (Table 9) mean concentrations for 19 parameters for the Vineland and Landis effluents out of 48 parameters analyzed were found to be significantly greater than the corresponding parameter means for the control groundwater. In the following discussion, references to these parameters are frequently made in order to trace the relative changes that occur as the Vineland and Landis treatment plant effluents percolate to the groundwater.

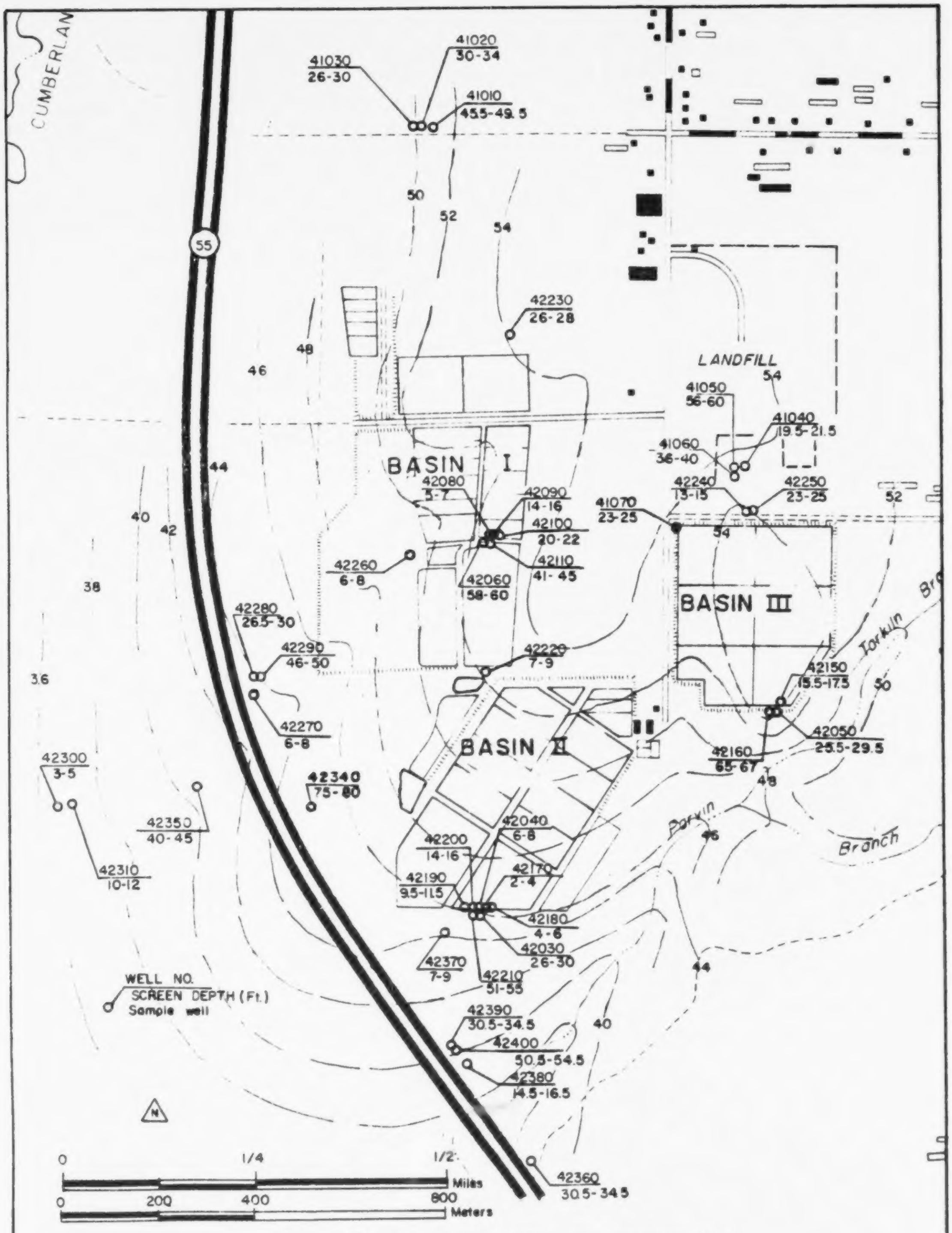

CUMBERLAND
55
41030
26-30
41020
30-34
41010
45.5-49.5
50
52
54
42230
26-28
48
46
LANDFILL
54
41050
56-60
41040
19.5-21.5
41060
36-40
BASIN I
44
42080
3-7
42090
14-16
42100
20-22
42110
41-45
42060
58-60
41070
23-25
42240
13-15
42250
23-25
52
54
40
42
38
42260
6-8
BASIN III
42280
26.5-30
42290
46-50
42220
7-9
Torkiln Branch
36
42270
6-8
42150
15.5-17.5
50
BASIN II
42050
25.5-29.5
42160
65-67
48
42300
3-5
42340
75-80
42350
40-45
Parvin Branch
46
42310
10-12
42040
6-8
42200
14-16
42170
2-4
42190
9.5-11.5
42180
4-6
42030
26-30
42370
7-9
42210
51-55
44
WELL NO.
SCREEN DEPTH (Ft.)
Sample well
42390
30.5-34.5
40
42400
50.5-54.5
42380
14.5-16.5
N
0
1/4
1/2
Miles
0
200
400
800
Meters
42360
30.5-34.5

Figure 13. Sample well location map Vineland, N. J.

The first analysis compared mean parameter concentrations for the test groundwater below the Vineland Basin I to those for the control groundwater. Specifically, the test groundwater well numbers are 42060, 42080, 42090, 42100, and 42110. The control site wells were 41010, 41020, and 41030. The results are shown in Table 10. Mean concentrations for 17 parameters--pH, conductivity, total alkalinity, dissolved solids, $BOD_5$, chloride, dissolved organic carbon, soluble organic nitrogen, ammonia, soluble phosphorus, soluble orthosphosphate, boron, calcium, iron, magnesium, potassium, and sodium--were found to be significantly greater in the test groundwater than in the control groundwater. With the exception of iron, the remaining 16 parameters were significantly greater in the Vineland effluent compared to the control wells, suggesting possible leaching for these constituents. Only dissolved oxygen was found to be significantly greater in the control wells than in the test groundwater. The average concentrations for many of the metals were below the detection limits in the test groundwater. At least one sample of the test groundwater had total and fecal coliform results TNTC which prevented statistical comparison to the control groundwater. For the remaining parameters, no significant difference at the 0.05 level was found between the test and the control groundwaters.

In the next analysis, means for the test groundwater below Landis Basin II were compared to those for the control groundwater. Test groundwater for Landis Basin II is identified from well numbers 42030, 42040, 42170, 42180, 42190, 42200, and 42210. The results in Table 11 show significantly greater means for 19 parameters in the test groundwater of Basin II compared to the control groundwater. Means for 17 of these parameters were significantly greater in the Landis effluent than in the control groundwater, suggesting possible leaching for these constituents. Specifically, these 17 parameters are pH, conductivity, total alkalinity, dissolved solids, $BOD_5$, COD, chloride, dissolved organic carbon, soluble organic nitrogen, ammonia, soluble phosphorus, soluble orthophosphorus, boron, calcium, magnesium, potassium, and sodium. In addition, mean concentrations for lindane and iron were also significantly greater in the test groundwater. Dissolved oxygen and nitrate concentrations were significantly greater in the control groundwater than in the test groundwater. For many of the metals, average concentrations were below detection limits for the test and control groundwaters. Also, at least one sample of the test groundwater analyzed had total and fecal coliforms too numerous to count. For the remaining parameters, no significant differences between the test and control groundwaters were found.

Parameter means for test groundwater below Landis Basin III were compared to those for the control groundwater. Test groundwater wells were numbers 42050, 42150, and 42160. Means for 16 parameters were significantly greater for the Landis Basin III groundwater than for the control groundwater (Table 12). Thirteen of the parameters--pH, conductivity, total alkalinity, dissolved solids, COD, chloride, dissolved organic carbon, soluble organic nitrogen, ammonia, boron, magnesium, potassium, and sodium--were previously found to have mean concentrations significantly greater for the Landis effluent than for the control wells, thus suggesting possible leaching for these constituents. Arsenic, iron, and manganese were the other three parameters with mean concentrations greater in the test groundwater than in the control groundwater. Only dissolved oxygen was observed to have a mean

TABLE 10. MEAN CONCENTRATIONS OF PARAMETERS IN CONTROL SITE GROUNDWATER AND TEST GROUNDWATER BELOW BASIN I

| Parameter | Means (mg/L unless noted) | |
|---|---|---|
| | Control | Test (Basin I) |
| Dissolved Oxygen | 8.8 | 0.4[a] |
| pH (units) | 5.2 | 6.6[a] |
| Conductivity (μmhos/cm) | 64 | 468[a] |
| Total Alkalinity | 7 | 119[a] |
| Dissolved Solids | 40 | 226[a] |
| Biochemical Oxygen Demand | 1.1 | 6.5[a] |
| Chemical Oxygen Demand | 7 | 75 |
| Chloride | 4 | 27[a] |
| Sulfide-S | 0.1[b] | 5.7 |
| Total Coliform (#/100 mL) | 51 | TNTC[c] |
| Fecal Coliform (#/100 mL) | 0 | TNTC |
| Dissolved Organic C | 0.8 | 21.9[a] |
| Soluble Organic N | 1.8 | 10.6[a] |
| Ammonium-N | 0.1 | 11.6[a] |
| Nitrate-N | 1.0 | 1.49 |
| Soluble Phosphorus | 0.08 | 1.69[a] |
| Soluble Orthophosphate | 0.03 | 1.54[a] |
| Sulfate | 9 | 22 |
| Aluminum | 1.8 | 0.5[b] |
| Arsenic (μg/L) | 6 | 10 |
| Boron (μg/L) | 113 | 332[a] |
| Cadmium (μg/L) | 20[b] | 20[b] |
| Calcium | 3 | 14[a] |
| Cobalt (μg/L) | 50[b] | 50[b] |
| Chromium (μg/L) | 20[b] | 20[b] |
| Copper (μg/L) | 20[b] | 23 |
| Iron | 1.6 | 12.6[a] |
| Lead (μg/L) | 100[b] | 100[b] |
| Magnesium | 1 | 5[a] |
| Manganese | 0.11 | 0.13 |
| Mercury (μg/L) | 1[b] | 1[b] |
| Nickel (μg/L) | 100[b] | 100[b] |
| Potassium | 1.2 | 10.6[a] |
| Sodium | 2 | 38[a] |
| Zinc (μg/L) | 43 | 525 |
| Selenium (μg/L) | 10[b] | 10[b] |
| Endrin (ng/L) | 0.03[b] | 0.03[b] |
| Lindane (ng/L) | 21.3 | 453 |
| Methoxychlor (ng/L) | 0.01[b] | 0.01[b] |
| Toxaphene (ng/L) | 0.1[b] | 0.1[b] |
| 2,4-D (ng/L) | 10.4 | 16.4 |
| 2,4,5 TP Silvex (ng/L) | 185 | 26.8 |

[a] Test and control sites are significantly different at the 0.05 level.
[b] Average concentrations below detection limit indicated.
[c] TNTC - At least one sample too numerous to count.

TABLE 11. MEAN CONCENTRATIONS OF PARAMETERS IN CONTROL SITE GROUNDWATER AND TEST GROUNDWATER BELOW BASIN II

| Parameter | Means (mg/L unless noted) | |
|---|---|---|
| | Control | Test (Basin II) |
| Dissolved Oxygen | 8.8 | 0.2[a] |
| pH (units) | 5.2 | 6.9[a] |
| Conductivity (μmhos/cm) | 64 | 688[a] |
| Total Alkalinity | 7 | 187[a] |
| Dissolved Solids | 40 | 381[a] |
| Biochemical Oxygen Demand | 1.1 | 12[a] |
| Chemical Oxygen Demand | 7 | 99[a] |
| Chloride | 4 | 79[a] |
| Sulfide-S | 0.1[b] | 16.5 |
| Total Coliform (#/100 mL) | 51 | TNTC[c] |
| Fecal Coliform (#/100 mL) | 0 | TNTC |
| Dissolved Organic C | 0.8 | 28[a] |
| Soluble Organic N | 1.8 | 11.0[a] |
| Ammonium-N | 0.1 | 17.5[a] |
| Nitrate-N | 1.0 | 0.06[a] |
| Soluble Phosphorus | 0.08 | 4.51[a] |
| Soluble Orthophosphate | 0.03 | 3.80[a] |
| Sulfate | 9 | 19 |
| Aluminum | 1.8 | 0.5[b] |
| Arsenic (μg/L) | 6 | 8 |
| Boron (μg/L) | 113 | 593[a] |
| Cadmium (μg/L) | 20[b] | 20[b] |
| Calcium | 3 | 9[a] |
| Cobalt (μg/L) | 50[b] | 50[b] |
| Chromium (μg/L) | 20[b] | 20[b] |
| Copper (μg/L) | 20[b] | 20[b] |
| Iron | 1.6 | 9.0[a] |
| Lead (μg/L) | 100[b] | 100[b] |
| Magnesium | 1 | 4[a] |
| Manganese | 0.11 | 0.09 |
| Mercury (μg/L) | 1[b] | 1[b] |
| Nickel (μg/L) | 100[b] | 100[b] |
| Potassium | 1.2 | 13.3[a] |
| Sodium | 2 | 102[a] |
| Zinc (μg/L) | 43 | 43 |
| Selenium (μg/L) | 10[b] | 10[b] |
| Endrin (ng/L) | 0.03[b] | 0.03[b] |
| Lindane (ng/L) | 21.3 | 1173[a] |
| Methoxychlor (ng/L) | 0.01[b] | 0.01[b] |
| Toxaphene (ng/L) | 0.1[b] | 0.1[b] |
| 2,4-D (ng/L) | 10.4 | 13.0 |
| 2,4,5 TP Silvex (ng/L) | 185 | 120 |

[a] Test and control sites are significantly different at the 0.05 level.
[b] Average concentrations below detection limit indicated.
[c] TNTC - At least one sample too numerous to count.

TABLE 12. MEAN CONCENTRATIONS OF PARAMETERS IN CONTROL SITE GROUNDWATER AND TEST GROUNDWATER BELOW BASIN III

| Parameter | Means (mg/L unless noted)<br>Control | <br>Test (Basin III) |
|---|---|---|
| Dissolved Oxygen | 8.8 | 0.3[a] |
| pH (units) | 5.2 | 6.6[a] |
| Conductivity (μmhos/cm) | 64 | 653[a] |
| Total Alkalinity | 7 | 161[a] |
| Dissolved Solids | 40 | 326[a] |
| Biochemical Oxygen Demand | 1.1 | 12.1 |
| Chemical Oxygen Demand | 7 | 80[a] |
| Chloride | 4 | 70[a] |
| Sulfide-S | 0.1[b] | 2.9 |
| Total Coliform (#/100 mL) | 51 | TNTC[c] |
| Fecal Coliform (#/100 mL) | 0 | 52 |
| Dissolved Organic C | 0.8 | 21.7[a] |
| Soluble Organic N | 1.8 | 6.1[a] |
| Ammonium-N | 0.1 | 10.6[a] |
| Nitrate-N | 1.0 | 0.34 |
| Soluble Phosphorus | 0.08 | 0.09 |
| Soluble Orthophosphate | 0.03 | 0.07 |
| Sulfate | 9 | 39 |
| Aluminum | 1.8 | 1.5 |
| Arsenic (μg/L) | 6 | 11[a] |
| Boron (μg/L) | 113 | 609[a] |
| Cadmium (μg/L) | 20[b] | 20[b] |
| Calcium | 3 | 10 |
| Cobalt (μg/L) | 50[b] | 50[b] |
| Chromium (μg/L) | 20[b] | 20[b] |
| Copper (μg/L) | 20[b] | 20[b] |
| Iron | 1.6 | 29.3[a] |
| Lead (μg/L) | 100[b] | 100[b] |
| Magnesium | 1 | 3[a] |
| Manganese | 0.11 | 0.53[a] |
| Mercury (μg/L) | 1[b] | 1[b] |
| Nickel (μg/L) | 100[b] | 100[b] |
| Potassium | 1.2 | 12.3[a] |
| Sodium | 2 | 86[a] |
| Zinc (μg/L) | 43 | 43 |
| Selenium (μg/L) | 10[b] | 10[b] |
| Endrin (ng/L) | 0.03[b] | 0.03[b] |
| Lindane (ng/L) | 21.3 | 227 |
| Methoxychlor (ng/L) | 0.01[b] | 0.01[b] |
| Toxaphene (ng/L) | 0.1[b] | 0.1[b] |
| 2,4-D (ng/L) | 10.4 | 13.2 |
| 2,4,5 TP Silvex (ng/L) | 185 | 27.5 |

[a] Test and control sites are significantly different at the 0.05 level.
[b] Average concentrations below detection limit indicated.
[c] TNTC - At least one sample too numerous to count.

centration significantly greater in the control groundwater. As in the previous analysis, average concentrations for many of the metals were below the detection limits in the test groundwater. At least one sample of the test groundwater analyzed total coliforms too numerous to count. For the remaining parameters, no significant differences in the means were found.

The next two analyses compared the test groundwaters of the three basins. Analysis A (Table 13) compared the test groundwater below Basin I with the test groundwater below Basin II. Table 13 shows significant differences for 14 parameter mean concentrations in analysis A. Twelve parameter means were significantly greater for the test groundwater below Basin II, whereas two parameters were greater for the test groundwater below Basin I. This probably reflects the heavier loadings on Basin II than on Basin I. Analysis B compared the test groundwater below Basin II with the test groundwater below Basin III. Analysis B showed significant differences for five parameters, with three means being greater for the test groundwater below Basin II and two means being greater for the test groundwater below Basin III. An overall observation from the two analyses is that loading quantities had greater effects on groundwater constituent concentrations than the relative length of time the systems have been operating.

An analysis was made to study the influence of leachate from the nearby landfill on test groundwater quality compared to the influence from the infiltration basins. The analysis consisted of comparing the mean concentrations of parameters for the test groundwater below the landfill to the test groundwater below Landis Basin III. Test groundwater wells for Basin III have been identified previously. The landfill groundwater wells are numbers 41040, 41050, and 41060. The results are shown in Table 14. The analysis showed mean concentrations for 16 parameters were significantly greater for the groundwater below Basin III than for the groundwater below the landfill. Also, 12 of the 16 parameter means were previously found to be significantly greater in the Landis effluent than in the control groundwater. The other four parameters not previously found to be significantly greater were arsenic, iron, manganese, and lindane. Only dissolved oxygen had a mean concentration greater in the landfill groundwater than in the test groundwater below Basin III. These results indicate the influence of the leachate from the landfill on groundwater quality to be significantly less than the influence from the infiltration basins.

The next group of analyses evaluated changes that occurred as the test groundwater moved downgradient from the basins. The first analysis compared the test groundwater below the Vineland Basin I with a group of downgradient wells. Test groundwater well numbers for Basin I have been identified previously. The downstream wells were numbers 42300, 42310, and 42350. The results in Table 15 show mean parameter concentrations for soluble orthophosphate and calcium were greater in the test groundwater below Basin I than in the groundwater of the downgradient wells. Mean concentrations for iron and manganese were significantly greater for the downgradient groundwater. Also shown in Table 15 is a comparison of the mean parameter concentrations for intermediate downgradient wells 42270, 42280, and 42290 with the downgradient wells 42300, 42310, and 42350. No significant differences were found for any of the parameters for this comparison.

TABLE 13. SUMMARY OF PARAMETER MEAN CONCENTRATION COMPARISONS BETWEEN THE TEST GROUNDWATER OF THE THREE BASINS

| Analysis Basin | A | | B | |
|---|---|---|---|---|
| Parameter | Vineland I | Landis II | Landis II | Landis III |
| Dissolved Oxygen | a | | | |
| pH (units) | | a | | |
| Conductivity (μmhos/cm) | | a | | |
| Total Alkalinity | | a | | |
| Dissolved Solids | | a | | |
| Biochemical Oxygen Demand | | a | | |
| Chemical Oxygen Demand | | | | |
| Chloride | | a | | |
| Sulfide-S | | | | |
| Total Coliform (#/100 mL) | | | | |
| Fecal Coliform (#/100 mL) | | | | |
| Dissolved Organic C | | | | |
| Soluble Organic N | | | | |
| Ammonium-N | | a | a | |
| Nitrate-N | | | | |
| Soluble Phosphorus | | a | a | |
| Soluble Orthophosphate | | a | a | |
| Sulfate | | | | |
| Aluminum | | | | |
| Arsenic (μg/L) | | | | |
| Boron (μg/L) | | a | | |
| Cadmium (μg/L) | | | | |
| Calcium | | | | |
| Cobalt (μg/L) | | | | |
| Chromium (μg/L) | | | | |
| Copper (μg/L) | | | | |
| Iron | | | | a |
| Lead (μg/L) | | | | |
| Magnesium | | | | |
| Manganese | a | | | a |
| Mercury (μg/L) | | | | |
| Nickel (μg/L) | | | | |
| Potassium | | a | | |
| Sodium | | a | | |
| Zinc (μg/L) | | | | |
| Selenium (μg/L) | | | | |
| Endrin (ng/L) | | | | |
| Lindane (ng/L) | | | | |
| Methoxychlor (ng/L) | | | | |
| Toxaphene (ng/L) | | | | |
| 2,4-D (ng/L) | | | | |
| 2,4,5 TP Silvex (ng/L) | | | | |

---

[a] Mean concentrations are significantly different at the 0.05 level for the basin test groundwater.

TABLE 14. MEAN CONCENTRATIONS OF PARAMETERS IN THE GROUNDWATER BENEATH THE LANDFILL AND BASIN III

| Parameter | Means (mg/L unless noted)<br>Landfill | <br>Basin III |
|---|---|---|
| Dissolved Oxygen | 3.7 | 0.3[a] |
| pH (units) | 4.8 | 6.6[a] |
| Conductivity (μmhos/cm) | 242 | 653[a] |
| Total Alkalinity | 4 | 161[a] |
| Dissolved Solids | 168 | 326[a] |
| Biochemical Oxygen Demand | 2 | 12.1 |
| Chemical Oxygen Demand | 10 | 80[a] |
| Chloride | 51 | 70 |
| Sulfide-S | 0.1[b] | 2.9 |
| Total Coliform (#/100 mL) | 33 | TNTC[c] |
| Fecal Coliform (#/100 mL) | 10 | 52 |
| Dissolved Organic C | 5.8 | 21.7[a] |
| Soluble Organic N | 0.8 | 6.1[a] |
| Ammonium-N | 1.4 | 10.6[a] |
| Nitrate-N | 0.31 | 0.34 |
| Soluble Phosphorus | 0.05 | 0.09 |
| Soluble Orthophosphate | 0.03 | 0.07 |
| Sulfate | 6 | 39[a] |
| Aluminum | 0.5 | 1.5 |
| Arsenic (μg/L) | 4 | 11[a] |
| Boron (μg/L) | 68 | 609[a] |
| Cadmium (μg/L) | 20[b] | 20[b] |
| Calcium | 3 | 10 |
| Cobalt (μg/L) | 50[b] | 50[b] |
| Chromium (μg/L) | 20[b] | 20[b] |
| Copper (μg/L) | 23 | 20[b] |
| Iron | 0.2 | 29.3[a] |
| Lead (μg/L) | 100[b] | 100[b] |
| Magnesium | 3 | 3 |
| Manganese | 0.21 | 0.53[a] |
| Mercury (μg/L) | 3 | 1[b] |
| Nickel (μg/L) | 100[b] | 100[b] |
| Potassium | 1.4 | 12.3[a] |
| Sodium | 40 | 86[a] |
| Zinc (μg/L) | 46 | 43 |
| Selenium (μg/L) | 10[b] | 10[b] |
| Endrin (ng/L) | 0.03[b] | 0.03[b] |
| Lindane (ng/L) | 3 | 227[a] |
| Methoxychlor (ng/L) | 0.01[b] | 0.01[b] |
| Toxaphene (ng/L) | 0.1[b] | 0.1[b] |
| 2,4-D (ng/L) | 4.8 | 13.2 |
| 2,4,5 TP Silvex (ng/L) | 21.8 | 27.5 |

[a] Landfill and Basin III sites are significantly different at the 0.05 level.
[b] Average concentrations below detection limit indicated.
[c] TNTC - At least one sample too numerous to count.

TABLE 15. MEAN CONCENTRATIONS OF PARAMETERS IN THE GROUNDWATERS BENEATH BASIN I, DOWNGRADIENT AND INTERMEDIATE WELLS

| Parameter | Means (mg/L unless noted) | | |
|---|---|---|---|
| | Basin I | Downgradient Wells | Intermediate Wells |
| Dissolved Oxygen | 0.4 | 0.1 | 0.4 |
| pH (units) | 6.6 | 6.6 | 6.8 |
| Conductivity (μmhos/cm) | 468 | 395 | 486 |
| Total Alkalinity | 119 | 169 | 189 |
| Dissolved Solids | 226 | 174 | 211 |
| Biochemical Oxygen Demand | 6.5 | 4.0 | 4.3 |
| Chemical Oxygen Demand | 75 | 53 | 34 |
| Chloride | 27 | 26 | 34 |
| Sulfide-S | 5.7 | 0.1[b] | 0.1[b] |
| Total Coliform (#/100 mL) | TNTC[c] | TNTC | 28 |
| Fecal Coliform (#/100 mL) | TNTC | 0 | 0 |
| Dissolved Organic C | 21.9 | 14.2 | 19.6 |
| Soluble Organic N | 10.6 | 8.5 | 5.6 |
| Ammonium-N | 11.6 | 9.8 | 10.1 |
| Nitrate-N | 1.49 | 0.05 | 0.12 |
| Soluble Phosphorus | 1.69 | 0.42 | 0.30 |
| Soluble Orthophosphate | 1.54 | 0.02[a] | 0.18 |
| Sulfate | 22 | 20 | 14 |
| Aluminum | 0.5[b] | 2.4 | 0.5[b] |
| Arsenic (μg/L) | 10 | 6 | 7 |
| Boron (μg/L) | 332 | 302 | 395 |
| Cadmium (μg/L) | 20[b] | 20[b] | 20[b] |
| Calcium | 14 | 6[a] | 17 |
| Cobalt (μg/L) | 50[b] | 50[b] | 50[b] |
| Chromium (μg/L) | 20[b] | 20[b] | 20[b] |
| Copper (μg/L) | 23 | 20[b] | 20[b] |
| Iron | 12.6 | 38.5[a] | 37.7 |
| Lead (μg/L) | 100[b] | 100[b] | 100[b] |
| Magnesium | 5 | 4 | 5 |
| Manganese | 0.13 | 0.45[a] | 0.33 |
| Mercury (μg/L) | 1[b] | 1[b] | 1[b] |
| Nickel (μg/L) | 100[b] | 100[b] | 100[b] |
| Potassium | 10.6 | 8.2 | 9.6 |
| Sodium | 38 | 37 | 47 |
| Zinc (μg/L) | 525 | 44 | 46 |
| Selenium (μg/L) | 10[b] | 10[b] | 10[b] |
| Endrin (ng/L) | 0.03[b] | 0.03[b] | 0.03[b] |
| Lindane (ng/L) | 453 | 64 | 78 |
| Methoxychlor (ng/L) | 0.01[b] | 0.01[b] | 0.01[b] |
| Toxaphene (ng/L) | 0.1[b] | 0.1[b] | 0.1[b] |
| 2,4-D (ng/L) | 16.4 | 13.3 | 15.1 |
| 2,4,5 TP Silvex (ng/L) | 26.8 | 40.9 | 33.9 |

[a] Basin I and downgradient sites are significantly different at the 0.05 level.
[b] Average concentrations below detection limit indicated.
[c] TNTC - At least one sample too numerous to count.

A similar analysis was made for wells downgradient from Landis Basin II (42380, 42390, and 42400). The mean parameter concentrations for the downgradient groundwater were compared to those of Basin II test groundwater. The results in Table 16 show mean concentrations for BOD, COD, soluble phosphorus, soluble orthophosphate, boron, calcium, and lindane were significantly greater in the test groundwater below Basin II than in the groundwater of the downgradient wells. Mean concentrations for iron and manganese were greater for the downgradient wells. These results indicate the change in groundwater quality is greater from the groundwater below Basin II to downgradient wells than from the groundwater below Basin I to downgradient wells and probably reflects the greater loading rates on the Landis basins.

## Groundwater Quality

The salient groundwater quality parameters that differentiated the test and control sites are discussed in more detail in the following paragraphs. In all cases, these parameters were present in the infiltration waters at concentrations greater than occurred in incident precipitation. The complete list and data for groundwater quality parameters are tabulated in Appendix B.

### Nitrogen--

Ammonium nitrogen concentrations in the Vineland effluent ranged from 5 to 25.1 mg/L. Ammonium nitrogen concentrations in the groundwater beneath Vineland Basin I varied from 0.5 to 26.7 mg/L (Figure 14). The lowest concentrations, in a range up to 9 mg/L, were encountered in the August sampling at a time when nitrification activity could be expected to be at a maximum. The ammonium nitrogen concentration in the effluent in August, 1976 was 5 mg/L. The highest concentrations, in a range between 12 and 26.7 mg/L were encountered in the December sampling at a time when nitrification activity could be expected to be at a minimum because of low temperatures. At intermediate observation periods, ammonia nitrogen concentrations were also at intermediate levels. This variation was particularly evident at monitoring well locations located immediately downgradient from the infiltration basin. At monitoring locations further downgradient, ammonia nitrogen concentrations continued to vary with time of year and did not show major decreases in concentration with distance from the basin source within the area monitored in this study. At a given well location, concentrations generally were relatively constant down to depths of 8 to 9 m (26 to 30 ft) but decreased at a depth of 17 to 18 m (56 to 59 ft) which is probably near the bottom of the wastewater plume at this location. Lower concentrations in the shallowest downgradient wells 42270 and 42300 indicate dilution from recharge and that the main plume of infiltrated wastewater is beginning to move below these depths.

Ammonium nitrogen concentrations in groundwater beneath Landis Basin II varied from 1.4 to 29.8 mg/L with no correlation observed with time of year. Groundwater below Basin II could be affected by Basins I and III as well as the upstream landfill. Thus, it is possible that ammonium nitrogen components of flow emanting from these other sources might mask seasonal variations from Basin II. Observations concerning concentration gradients along

TABLE 16. MEAN CONCENTRATIONS OF PARAMETERS IN THE GROUNDWATERS BENEATH BASIN II AND DOWNGRADIENT WELLS

| Parameter | Means (mg/L unless noted) | |
|---|---|---|
| | Basin II | Downgradient Wells |
| Dissolved Oxygen | 0.2 | 0.5 |
| pH (units) | 6.9 | 6.9 |
| Conductivity (μmhos/cm) | 688 | 729 |
| Total Alkalinity | 187 | 211 |
| Dissolved Solids | 381 | 345 |
| Biochemical Oxygen Demand | 12 | 4.4[a] |
| Chemical Oxygen Demand | 99 | 40[a] |
| Chloride | 79 | 78 |
| Sulfide-S | 16.5 | 0.7 |
| Total Coliform (#/100 mL) | TNTC[c] | 4 |
| Fecal Coliform (#/100 mL) | TNTC | 0 |
| Dissolved Organic C | 28 | 13.9 |
| Soluble Organic N | 11.0 | 8.0 |
| Ammonium-N | 17.5 | 17.4 |
| Nitrate-N | 0.06 | 0.05 |
| Soluble Phosphorus | 4.51 | 0.27[a] |
| Soluble Orthophosphate | 3.80 | 0.11[a] |
| Sulfate | 19 | 4 |
| Aluminum | 0.5[b] | 0.5 |
| Arsenic (μg/L) | 8 | 10 |
| Boron (μg/L) | 593 | 486[a] |
| Cadmium (μg/L) | 20[b] | 20[b] |
| Calcium | 9 | 5[a] |
| Cobalt (μg/L) | 50[b] | 50[b] |
| Chromium (μg/L) | 20[b] | 20[b] |
| Copper (μg/L) | 20[b] | 20[b] |
| Iron | 9.0 | 33.6[a] |
| Lead (μg/L) | 100[b] | 100[b] |
| Magnesium | 4 | 4 |
| Manganese | 0.09 | 0.32[a] |
| Mercury (μg/L) | 1[b] | 1[b] |
| Nickel (μg/L) | 100[b] | 100[b] |
| Potassium | 13.3 | 14.6 |
| Sodium | 102 | 100 |
| Zinc (μg/L) | 43 | 20 |
| Selenium (μg/L) | 10[b] | 10[b] |
| Endrin (ng/L) | 0.03[b] | 0.03[b] |
| Lindane (ng/L) | 1173 | 70[a] |
| Methoxychlor (ng/L) | 0.01[b] | 0.01[b] |
| Toxaphene (ng/L) | 0.1[b] | 0.1[b] |
| 2,4-D (ng/L) | 13.0 | 10.7 |
| 2,4,5 TP Silvex (ng/L) | 120 | 35.4 |

[a] Basin II and downgradient sites are significantly different at the 0.05 level.

[b] Average concentrations below detection limit indicated.

[c] TNTC - At least one sample too numerous to count.

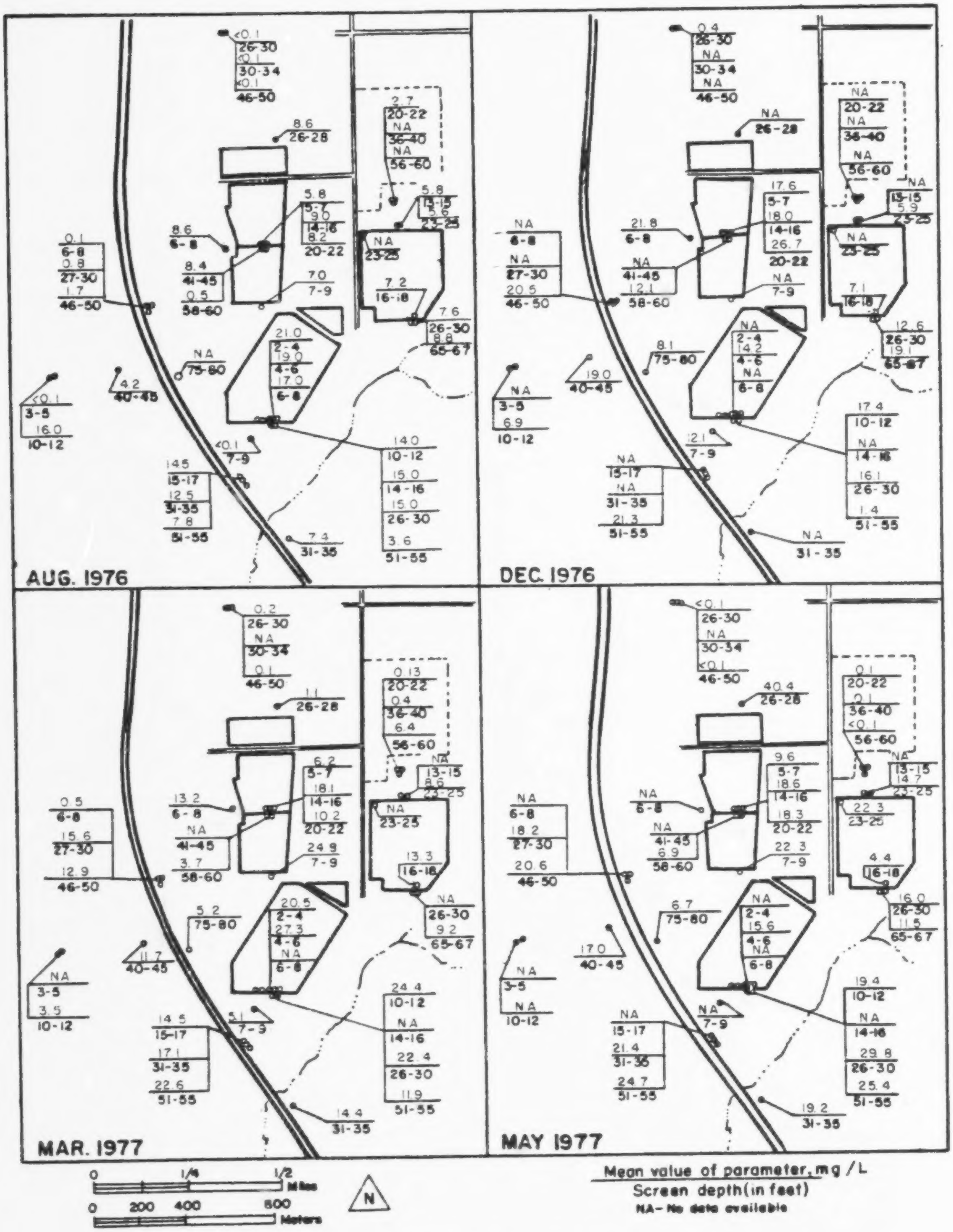

AUG. 1976
<0.1
26-30
<0.1
30-34
<0.1
46-50
8.6
26-28
2.7
20-22
NA
36-40
NA
56-60
5.8
5-7
9.0
14-16
8.2
20-22
5.8
13-15
5.6
23-25
8.6
6-8
8.4
41-45
0.5
58-60
NA
23-25
7.0
7-9
7.2
16-18
7.6
26-30
8.8
65-67
0.1
6-8
0.8
27-30
1.7
46-50
21.0
2-4
19.0
4-6
17.0
6-8
NA
75-80
4.2
40-45
<0.1
3-5
16.0
10-12
<0.1
7-9
14.0
10-12
15.0
14-16
15.0
26-30
3.6
51-55
14.5
15-17
12.5
31-35
7.8
51-55
7.4
31-35
DEC. 1976
0.4
26-30
NA
30-34
NA
46-50
NA
26-28
NA
20-22
NA
36-40
NA
56-60
NA
13-15
5.9
23-25
17.6
5-7
18.0
14-16
26.7
20-22
21.8
6-8
NA
41-45
12.1
58-60
NA
23-25
NA
7-9
7.1
16-18
12.6
26-30
19.1
65-67
NA
6-8
NA
27-30
20.5
46-50
NA
2-4
14.2
4-6
NA
6-8
8.1
75-80
19.0
40-45
NA
3-5
6.9
10-12
12.1
7-9
17.4
10-12
NA
14-16
16.1
26-30
1.4
51-55
NA
15-17
NA
31-35
21.3
51-55
NA
31-35
MAR. 1977
0.2
26-30
NA
30-34
0.1
46-50
1.1
26-28
0.13
20-22
0.4
36-40
6.4
56-60
6.2
5-7
18.1
14-16
10.2
20-22
NA
13-15
8.5
23-25
13.2
6-8
NA
41-45
3.7
58-60
NA
23-25
24.9
7-9
13.3
16-18
NA
26-30
9.2
65-67
0.5
6-8
15.6
27-30
12.9
46-50
20.5
2-4
27.3
4-6
NA
6-8
5.2
75-80
11.7
40-45
NA
3-5
3.5
10-12
24.4
10-12
NA
14-16
22.4
26-30
11.9
51-55
14.5
15-17
17.1
31-35
22.6
51-55
5.1
7-9
14.4
31-35
MAY 1977
<0.1
26-30
NA
30-34
<0.1
46-50
40.4
26-28
0.1
20-22
0.1
36-40
<0.1
56-60
NA
13-15
14.7
23-25
9.6
5-7
18.6
14-16
18.3
20-22
NA
6-8
NA
41-45
6.9
58-60
22.3
23-25
22.3
7-9
4.4
16-18
16.0
26-30
11.5
65-67
NA
6-8
18.2
27-30
20.6
46-50
NA
2-4
15.6
4-6
NA
6-8
6.7
75-80
17.0
40-45
NA
3-5
NA
10-12
19.4
10-12
NA
14-16
29.8
26-30
25.4
51-55
NA
15-17
21.4
31-35
24.7
51-55
NA
7-9
19.2
31-35
0
1/4
1/2
Miles
0
200
400
800
Meters
N
Mean value of parameter, mg/L
Screen depth (in feet)
NA- No data available

**Figure 14. Groundwater constituents.**- Ammonium Nitrogen

the path of groundwater travel and with depth were the same as for Basin I.

Ammonium nitrogen concentrations in groundwater beneath Landis Basin III varied from 4.4 to 19.1 mg/L and varied with time of year in a manner consistent with Basin I. Typical August concentrations were generally highest with intermediate time periods also intermediate in concentration. Observations concerning concentration gradients along the path of groundwater travel and with depth were the same as for Basin I.

Ammonium nitrogen concentrations in groundwater downgradient from the landfill varied from <0.1 to 6.4 mg/L. Other observed concentrations were 0.1, 0.1, 0.13, 0.4, and 2.7 mg/L. The lowest and highest concentrations were both observed at the deepest monitoring point at 17 to 18 m (56 to 59 ft) below ground level. The highest concentration was observed in March and the lowest in May. There was also a possibility that these monitoring wells, which were located over a saddle on the saturated zone surface, could at times receive ammonium nitogen contributions direct from Basin III.

Control groundwater concentrations of ammonium nitrogen varied from <0.1 to 0.4 mg/L and averaged <0.15 mg/L. Thus background concentrations were essentially at minimum detectable concentrations.

The overall observation was that ammonium nitrogen was exiting the groundwater area monitored in this study in large amounts. Immediately beneath Basin I the groundwater contained 68 percent of the amount of applied ammonium nitrogen; beneath Basin II, the groundwater contained 92 percent and groundwater beneath Basin III contained only 56 percent of the applied ammonium nitrogen. An analysis of Basin I, using wells 42280, 42290, 42310, and 42350 with an average concentration of 12 mg/L, is representative of the overall groundwater leaving Area I. This analysis indicated that 70 percent of the ammonium nitrogen is exiting via the groundwater. Well 42300 was excluded from the averages because other parameters such as chloride, conductivity, and alkalinity indicated that it is above the wastewater plume at that location. Although less obvious, the same parameters indicate that concentrations in shallow well 42270 could be diluted by recharge from onsite precipitation.

If wells 42380, 42390, and 42400 are regarded as overall discharge monitoring wells for Area II, the average measured discharge concentration is 17.3 mg/L. The weighted average applied ammonium nitrogen concentration was 19 mg/L and therefore an estimated 91 percent of the applied ammonium nitrogen could be leaving Area II via the groundwater. Well 42360 across Parvin Branch which probably receives some dilution from the southwest and/or flow from Basin III was not included as a downgradient well for Basin II.

Some of this exiting ammonium nitrogen would likely originate from the organic nitrogen component of the primary effluent as a result of biodegradation in the infiltrated soils. The evidence suggested that the program of alternate flooding and drying, as practiced at Vineland and Landis, was controlling ammonium nitrogen discharge to the groundwater to a limited extent at Vineland Basin I and Landis Basin III. The limited control at Vineland Basin I was probably related to the lower loading rates whereas the better performance of Basin III was probably affected by length of service but due primarily to the greater thickness of the unsaturated zone. The unsaturated zone beneath Basin III was 3.7 m (12 ft) as contrasted to 0.8 m (2.7 ft) beneath Basin II which is loaded at an equivalent rate. Overall, the control of ammonia nitrogen at the combined site was not effective and the ammonia nitrogen concentrations exceed safe standards for healthy aquatic life.

Nitrogen (organic)--The soluble organic nitrogen concentrations applied to the infiltration basins ranged between 3.0 and 27.6 mg/L with an average of 16.8 mg/L at Vineland Basin I and ranged between 15.9 and 25.4 mg/L with an average of 21.1 mg/L at Landis Basins II and III. The soluble organic nitrogen concentrations in groundwater beneath and downgradient from Basin I, II, and III varied from 0.1 to 41.6 mg/L (Figure 15) and were variable in seasonal characteristics in gradients along direction of groundwater travel and with depth. Using wells beneath each basin as monitoring points, Basin I has an average concentration of discharge of 10.6 mg/L, Basin II had 11.0 mg/L and Basin III had 6.1 mg/L. This corresponds to passage of organic nitrogen concentration of 63 percent for Basin I, 52 percent for Basin II and 29 percent for Basin III. Of the individual basins, Landis Basin III appears to be most effectively converting organic nitrogen to other forms of nitrogen. The average concentration of wells 42028, 42029, 42031, and 42035 downgradient from Vineland Basin I was 7.7 mg/L and indicated that 46 percent of the applied soluble organic nitrogen was exiting Area I. Average concentration of wells 42380, 42390, and 42400 downgradient from Landis Basin II was 8.0 mg/L and indicated 44 percent passage.

The organic nitrogen concentrations leaving the Vineland and Landis treatment sites although decreasing slightly downgradient are excessive and are potentially a problem because of their likely natural conversion to other nitrogen forms such as ammonia and nitrate.

Groundwater downgradient from the landfill wells 41040, 41050, and 41060 was contributing soluble organic nitrogen concentrations in the range of <0.1 to 1.5 mg/L with an average of 0.8 mg/L. Control groundwater contained concentrations that ranged from 0.2 to 9.5 mg/L and averaged 1.8 mg/L. The 9.5 mg/L appears to be an anomolous value which if excluded would leave a range of 0.2 to 1.0 mg/L. Thus, little if any orgainc nitrogen entered the treatment site groundwater as a result of the landfill or the upstream control water.

Nitrogen (nitrate)--The nitrate nitrogen concentrations applied via the primary effluents ranged <0.1 to 3.7 mg/L. Nitrate nitrogen was essentially absent in the treatment monitoring wells at a detectable limit of <0.1 mg/L (Figure 16). A few sporadic readings occasionally occurred in the shallowest monitoring wells indicating that some nitrification may be occurring near the top of the water table.

Nitrate nitrogen concentrations in groundwater downgradient from the landfill ranged from <0.1 to 0.6 mg/L with an average of 0.3 mg/L. Control groundwater had a nitrate nitrogen concentration range of <0.1 to 2.6 mg/L and an average of 1.0 mg/L. Thus very little nitrate nitrogen was contributed

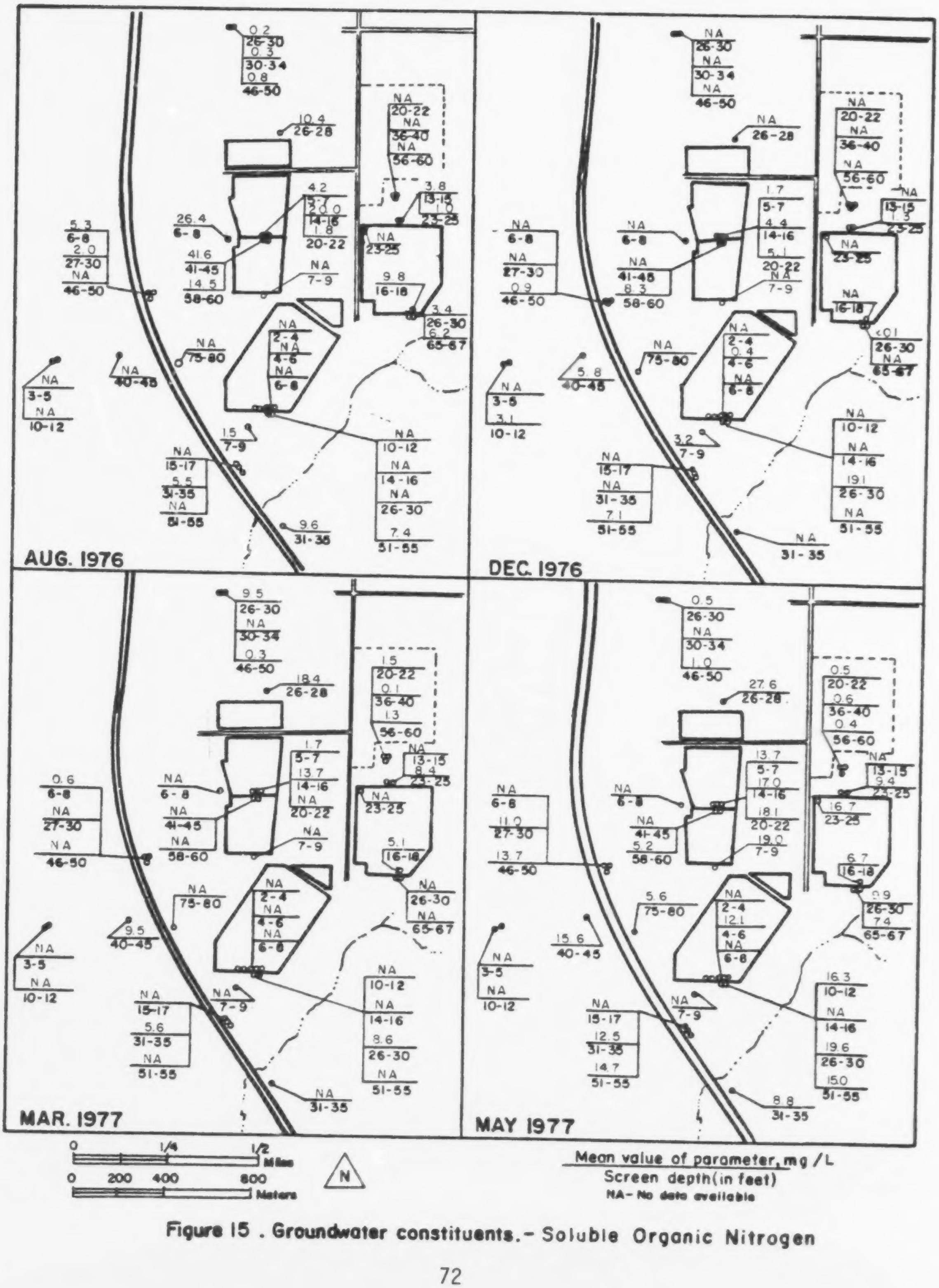

AUG. 1976
0.2
26-30
0.3
30-34
0.8
46-50
10.4
26-28
NA
20-22
NA
36-40
NA
56-60
4.2
5-7
20.0
14-16
1.8
20-22
3.8
13-15
1.0
23-25
26.4
6-8
41.6
41-45
14.5
58-60
5.3
6-8
2.0
27-30
NA
46-50
NA
23-25
NA
7-9
9.8
16-18
3.4
26-30
6.2
65-67
NA
2-4
NA
4-6
NA
6-8
NA
75-80
NA
40-45
NA
3-5
NA
10-12
1.5
7-9
NA
15-17
5.5
31-35
NA
51-55
NA
10-12
NA
14-16
NA
26-30
7.4
51-55
9.6
31-35
DEC. 1976
NA
26-30
NA
30-34
NA
46-50
NA
26-28
NA
20-22
NA
36-40
NA
56-60
1.7
5-7
4.4
14-16
5.1
20-22
NA
13-15
1.3
23-25
NA
6-8
NA
41-45
8.3
58-60
NA
6-8
NA
27-30
0.9
46-50
NA
23-25
NA
7-9
NA
16-18
<0.1
26-30
NA
65-67
NA
2-4
0.4
4-6
NA
6-8
NA
75-80
5.8
40-45
NA
3-5
3.1
10-12
3.2
7-9
NA
15-17
NA
31-35
7.1
51-55
NA
10-12
NA
14-16
19.1
26-30
NA
51-55
NA
31-35
MAR. 1977
9.5
26-30
NA
30-34
0.3
46-50
18.4
26-28
1.5
20-22
0.1
36-40
1.3
56-60
1.7
5-7
13.7
14-16
NA
20-22
NA
13-15
8.4
23-25
NA
6-8
NA
41-45
NA
58-60
0.6
6-8
NA
27-30
NA
46-50
NA
23-25
NA
7-9
5.1
16-18
NA
26-30
NA
65-67
NA
2-4
NA
4-6
NA
6-8
NA
75-80
9.5
40-45
NA
3-5
NA
10-12
NA
7-9
NA
15-17
5.6
31-35
NA
51-55
NA
10-12
NA
14-16
8.6
26-30
NA
51-55
NA
31-35
MAY 1977
0.5
26-30
NA
30-34
1.0
46-50
27.6
26-28
0.5
20-22
0.6
36-40
0.4
56-60
13.7
5-7
17.0
14-16
18.1
20-22
NA
13-15
9.4
23-25
NA
6-8
NA
41-45
5.2
58-60
NA
6-8
11.0
27-30
13.7
46-50
16.7
23-25
19.0
7-9
6.7
16-18
9.9
26-30
7.4
65-67
NA
2-4
12.1
4-6
NA
6-8
5.6
75-80
15.6
40-45
NA
3-5
NA
10-12
NA
7-9
NA
15-17
12.5
31-35
14.7
51-55
16.3
10-12
NA
14-16
19.6
26-30
15.0
51-55
8.8
31-35
0
1/4
1/2
Miles
0
200
400
800
Meters
N
Mean value of parameter, mg /L
Screen depth (in feet)
NA- No data available

Figure 15 . Groundwater constituents.- Soluble Organic Nitrogen

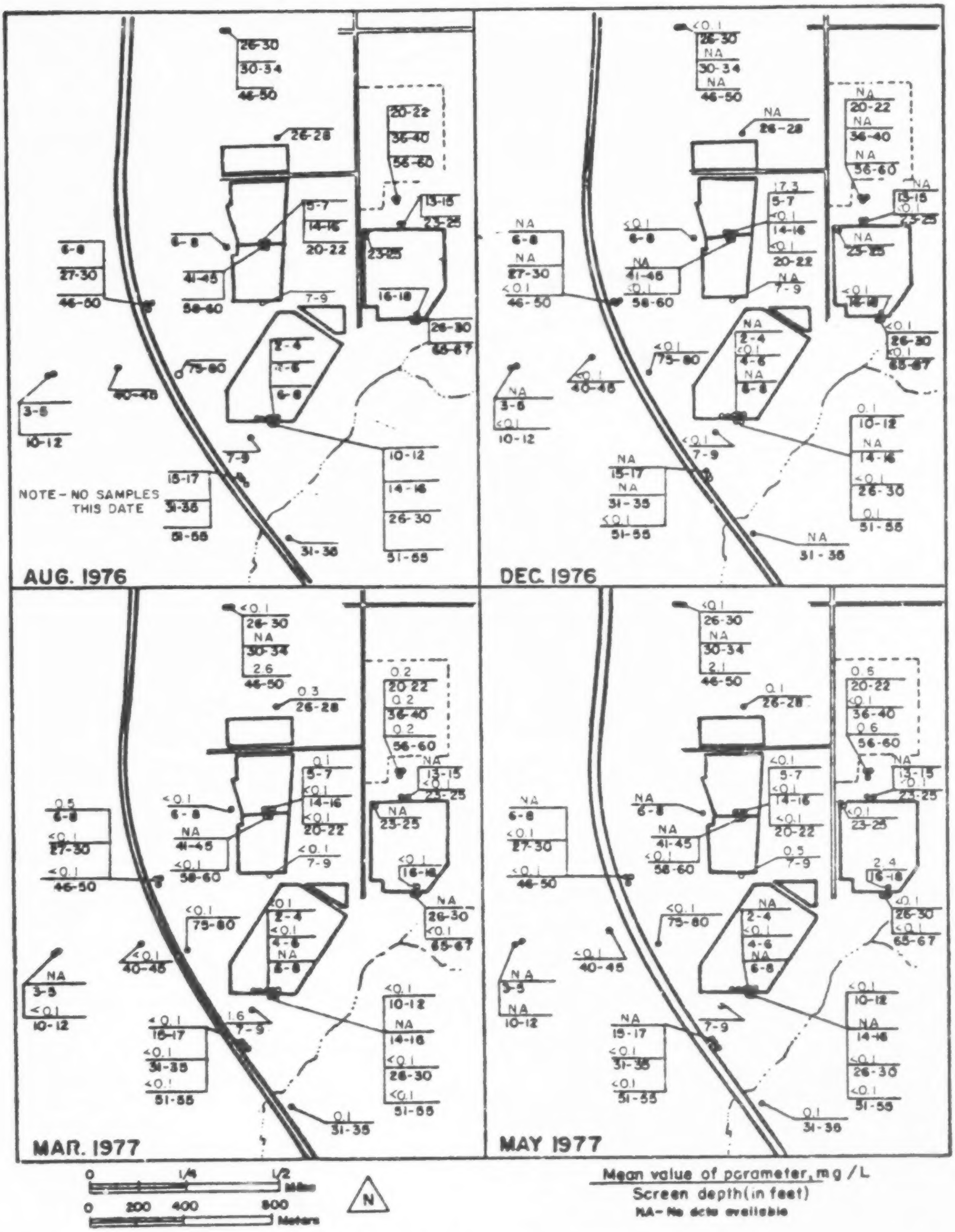

AUG. 1976
NOTE - NO SAMPLES THIS DATE
DEC. 1976
MAR. 1977
MAY 1977
26-30
30-34
46-50
26-28
20-22
36-40
56-60
13-15
23-25
5-7
14-16
20-22
6-8
41-45
58-60
7-9
6-8
27-30
46-50
16-18
26-30
65-67
2-4
4-6
6-8
75-80
40-45
3-5
10-12
10-12
14-16
26-30
51-55
15-17
31-35
51-55
31-35
NA
<0.1
17.3
0.1
0.2
0.3
0.5
0.6
1.6
2.1
2.4
2.6
0 1/4 1/2 Miles
0 200 400 800 Meters
N
Mean value of parameter, mg / L
Screen depth (in feet)
NA - No data available

Figure 16 . Groundwater constituents. - Nitrate Nitrogen to the treatment site groundwater from the upgradient landfill and background concentrations in control groundwater probably only contributed to the northernmost well 42230.

The weighted average applied effluent nitrate nitrogen concentration was 1.1 mg/L and this concentration was completely removed to a detectable concentration of <0.1 mg/L at the treatment site.

Nitrogen (total)--The total nitrogen concentration including total organic, ammonia and nitrate nitrogen applied to the Vineland Basin I on a weighted average basis was 40.4 mg/L. The total nitrogen leaving Area I via the groundwater as measured at wells 42280, 42290, 42310, and 42350 was 19.7 mg/L. Therefore, by approximate methods, 49 percent of the applied nitrogen was leaving Vineland Area I via the groundwater. A similar analysis of Landis Basin II, where an average of 47.7 mg/L total nitrogen was applied as compared to an average of 27.5 mg/L in wells 42380, 42390, and 42400, indicates that 58 percent of the applied nitrogen was leaving Area II via the groundwater.

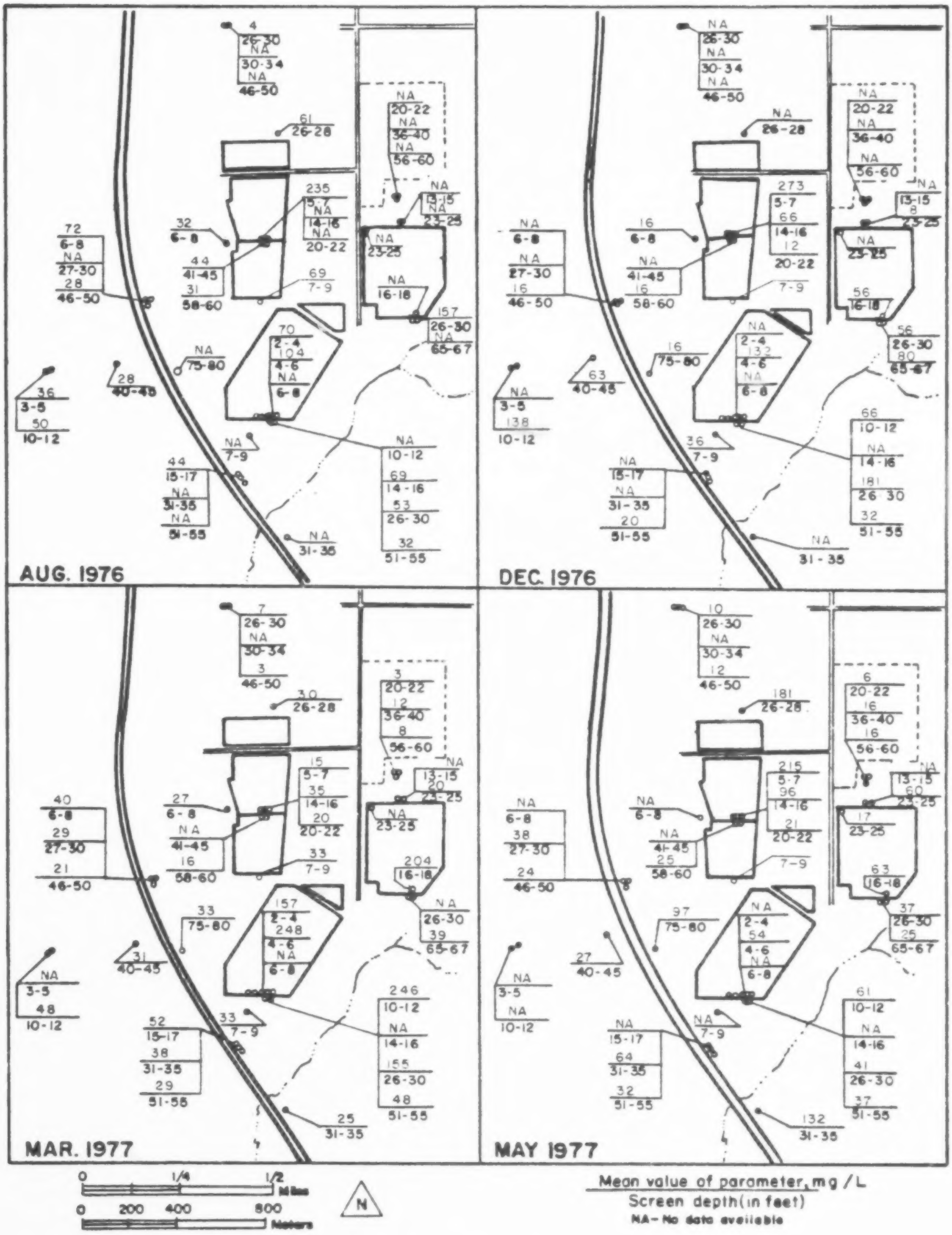
Although there was no suitable location for monitoring wells downgradient from Landis Basin III, it could be assumed that organic nitrogen would decrease downgradient and that the total nitrogen leaving Area III would be slightly less than the average concentration beneath the basin. Wells 42050, 42150, and 42160 have an average concentration of 14.6 mg/L ammonia nitrogen and 6.1 mg/L soluble organic nitrogen. The average total nitrogen applied was 47.7 mg/L and the average total nitrogen leaving Area III would probably be less than 43 percent of the applied amount.

Chemical Oxygen Demand--

The COD concentration of the applied effluents ranged from 237 to 472 mg/L. The COD concentration range of the groundwater beneath and downgradient from the infiltration basins was 12 to 273 mg/L (Figure 17). Concentrations varied irregularly with season but generally demonstrated a gradient with distance along path of groundwater travel and with depth. Residual concentrations were lowest and in the range of 20 to 32 mg/L for the deepest and farthest downgradient monitoring wells. This is consistent with results observed in other land treatment systems, where given sufficient distance of travel, the concentration of applied COD dropped to natural background concentrations.

The average COD concentration of the effluent applied to Basin I was 372 mg/L. The average concentration beneath the basin was 75 mg/L and the average downgradient concentration was 42 mg/L indicating that 11 percent of the applied concentration was passing the downgradient wells. Beneath the basin there were generally a decrease in concentration with depth and downgradient although these gradients are not as consistent as in Area II. As discussed elsewhere, this may be related to the lower loading rates and occasional clay layers within this area.

The average COD concentration of the effluent applied to Basin II was 287 mg/L. The average concentration beneath the basin was 99 mg/L and the average downgradient concentration was 40 mg/L which indicates 14 percent of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61 26-28
NA 20-22 NA 36-40 NA 56-60
235 5-7 NA 14-16 NA 20-22
NA 13-15 NA 23-25
32 6-8
44 41-45 31 58-60
72 6-8 NA 27-30 28 46-50
NA 23-25
69 7-9
NA 16-18
157 26-30 NA 65-67
70 2-4 104 4-6 NA 6-8
NA 75-80
36 3-5 50 10-12
28 40-45
NA 7-9
NA 10-12 69 14-16 53 26-30 32 51-55
44 15-17 NA 31-35 NA 51-55
NA 31-35
AUG. 1976
NA 26-30 NA 30-34 NA 46-50
NA 26-28
NA 20-22 NA 36-40 NA 56-60
273 5-7 66 14-16 12 20-22
NA 13-15 8 23-25
16 6-8
NA 41-45 16 58-60
NA 6-8 NA 27-30 16 46-50
NA 23-25
7-9
56 16-18
56 26-30 80 65-67
NA 2-4 132 4-6 NA 6-8
16 75-80
NA 3-5 138 10-12
63 40-45
36 7-9
66 10-12 NA 14-16 181 26-30 32 51-55
NA 15-17 NA 31-35 20 51-55
NA 31-35
DEC. 1976
7 26-30 NA 30-34 3 46-50
30 26-28
3 20-22 12 36-40 8 56-60
15 5-7 35 14-16 20 20-22
NA 13-15 20 23-25
27 6-8
NA 41-45 16 58-60
40 6-8 29 27-30 21 46-50
NA 23-25
33 7-9
204 16-18
NA 26-30 39 65-67
157 2-4 248 4-6 NA 6-8
33 75-80
NA 3-5 48 10-12
31 40-45
33 7-9
246 10-12 NA 14-16 155 26-30 48 51-55
52 15-17 38 31-35 29 51-55
25 31-35
MAR. 1977
10 26-30 NA 30-34 12 46-50
181 26-28
6 20-22 16 36-40 16 56-60
215 5-7 96 14-16 21 20-22
NA 13-15 60 23-25
NA 6-8
NA 41-45 25 58-60
NA 6-8 38 27-30 24 46-50
17 23-25
7-9
63 16-18
37 26-30 25 65-67
NA 2-4 54 4-6 NA 6-8
97 75-80
NA 3-5 NA 10-12
27 40-45
NA 7-9
61 10-12 NA 14-16 41 26-30 37 51-55
NA 15-17 64 31-35 32 51-55
132 31-35
MAY 1977
0 1/4 1/2 Miles
0 200 400 800 Meters
N
Mean value of parameter, mg / L
Screen depth (in feet)
NA - No data available

Figure 17 . Groundwater constituents.- COD the applied concentration was passing. There was an obvious decrease in concentration with depth and downgradient. It is interesting to compare the concentration of wells beneath the basin with downgradient wells of approximately the same depth. The average concentration of one 7.9 m (26 to 30 ft) deep well beneath the basin was 108 mg/L as compared to 51 mg/L for a 9.1 m (31 to 35 ft) downgradient well. Similarly the 15.5 m (51 to 55 ft) wells have concentrations beneath the basin of 37 mg/L and 27 mg/L downgradient.

With the same effluent and infiltration rates the average concentration beneath Basin III was 80 mg/L indicating that slightly better performance might be expected.

Groundwater flow from the landfill ranged in COD concentration from 3 to 16 mg/L with an average of 10 mg/L. Control groundwater concentrations ranged from 3 to 12 mg/L with an average of 7 mg/L. Thus only minor COD components were measured as contributing to the treatment site groundwater. Additional distance of travel of the treatment site tributary groundwater beyond the monitored study area can reasonably be expected to reduce the residual concentration to a final COD concentration approaching the background level of 7 mg/L.

### Chloride, Dissolved Solids, and Boron--

The concentrations of chloride and dissolved solids in the applied effluents ranged from 19 to 179 and 163 to 514 mg/L, respectively. The applied effluents boron concentration ranged from 34 to 642 μg/L (Table 8). The treatment site groundwater had a range of concentrations of 3 to 198 mg/L for chloride (Figure 18), 57 to 564 mg/L for dissolved solids (Figure 19), and 49 to 933 μg/L for boron (Figure 20). The concentrations for each of these parameters varied irregularly with period of sampling, distance along path of groundwater travel and with depth.

The major contributor to this variability was the concentration of the parameters in the applied effluent which were extremely variable at different sampling periods. For example, Vineland effluent chloride concentrations ranged from 19 to 42 mg/L for all sampling periods except the August, 1976, sampling at which time effluent chloride was 135 mg/L. Boron concentrations ranged from 347 to 460 μg/L except for the December, 1976, value of 34 μg/L. Likewise, all Landis effluent chloride samplings ranged from 19 to 77 mg/L in concentration except for the May, 1977, sampling which tested at 179 mg/L concentration. Dissolved solids also exhibited wide variability for single samplings.

The variability of parameter concentration is not unexpected and the average obtained from four samples must be viewed in that context. For example, it is unlikely that 25 percent of the time the concentration of boron in the Vineland effluent is only 34 μg/L.

Utilizing the previously designated representative wells, the average parameter concentrations beneath and downgradient from each basin is summarized in Table 17. The precent leaving the area as determined by the average downgradient concentration compared to the average effluent concentration is also shown in Table 17.

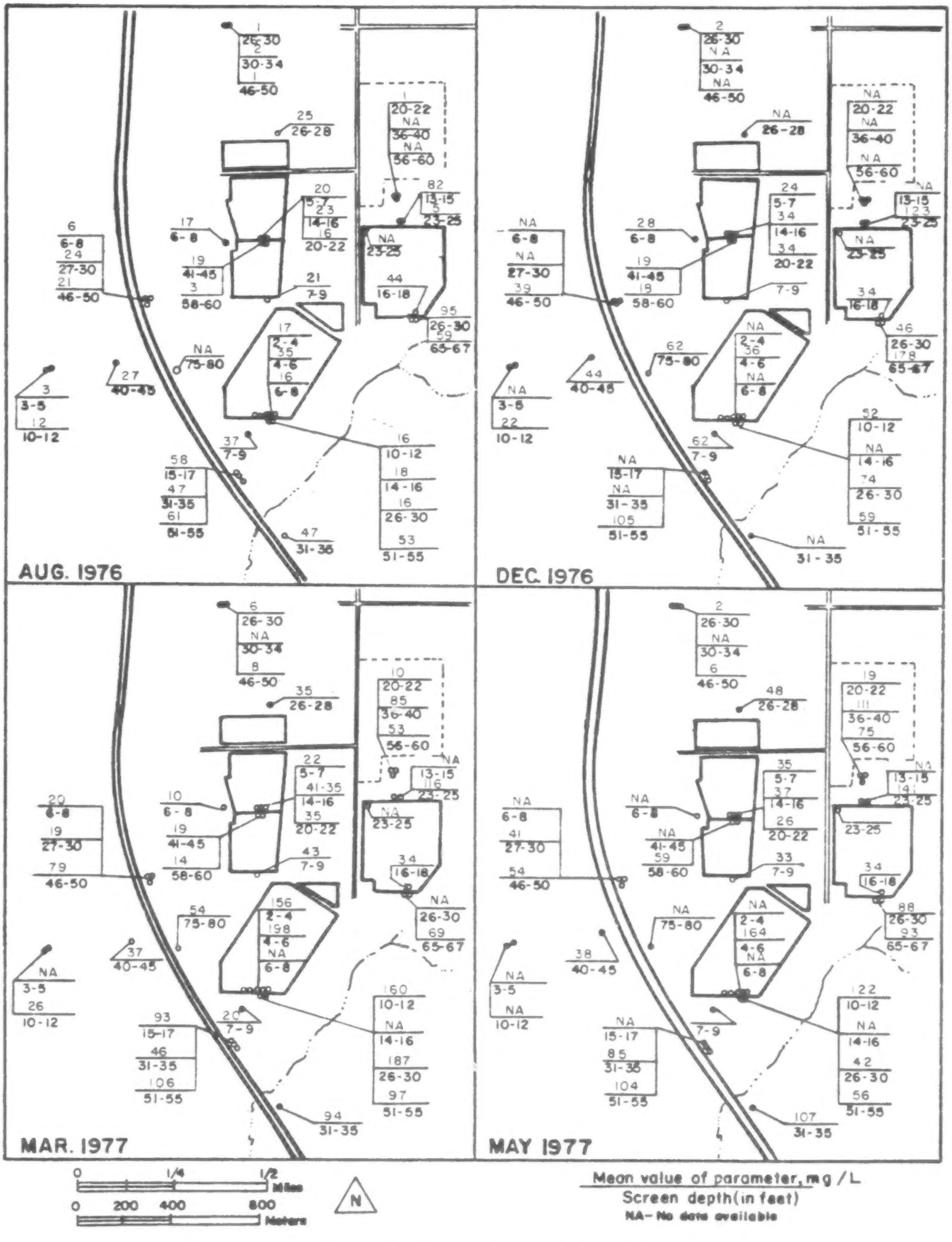
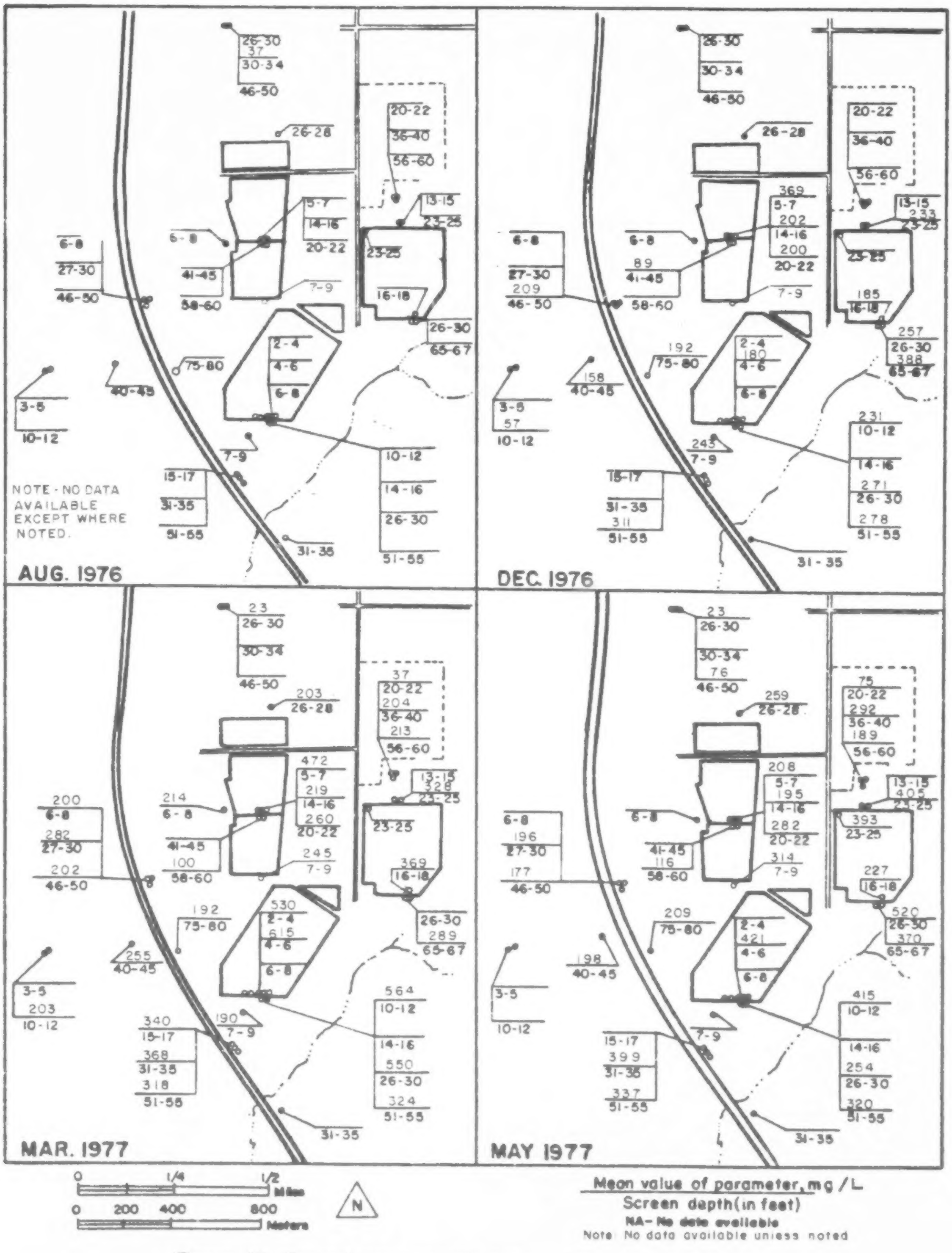

AUG. 1976
DEC. 1976
MAR. 1977
MAY 1977
0
1/4
1/2
Miles
0
200
400
800
Meters
N
Mean value of parameter, mg / L
Screen depth (in feet)
NA – No data available

Figure 18. Groundwater constituents.– Chloride



AUG. 1976
26-30
37
30-34
46-50
26-28
20-22
36-40
56-60
13-15
23-25
5-7
14-16
20-22
6-8
41-45
58-60
7-9
23-25
16-18
26-30
65-67
6-8
27-30
46-50
2-4
4-6
6-8
75-80
40-45
3-5
10-12
10-12
14-16
26-30
51-55
7-9
15-17
31-35
51-55
31-35
NOTE - NO DATA AVAILABLE EXCEPT WHERE NOTED.
DEC. 1976
26-30
30-34
46-50
26-28
20-22
36-40
56-60
13-15
233
23-25
369
5-7
202
14-16
200
20-22
6-8
89
41-45
58-60
7-9
6-8
27-30
209
46-50
23-25
185
16-18
257
26-30
388
65-67
192
75-80
2-4
180
4-6
6-8
158
40-45
3-5
57
10-12
231
10-12
14-16
271
26-30
278
51-55
243
7-9
15-17
31-35
311
51-55
31-35
MAR. 1977
23
26-30
30-34
46-50
203
26-28
37
20-22
204
36-40
213
56-60
13-15
328
23-25
472
5-7
219
14-16
260
20-22
214
6-8
41-45
100
58-60
245
7-9
200
6-8
282
27-30
202
46-50
23-25
369
16-18
26-30
289
65-67
192
75-80
530
2-4
615
4-6
6-8
255
40-45
3-5
203
10-12
564
10-12
14-16
550
26-30
324
51-55
340
15-17
368
31-35
318
51-55
190
7-9
31-35
MAY 1977
23
26-30
30-34
76
46-50
259
26-28
75
20-22
292
36-40
189
56-60
13-15
405
23-25
208
5-7
195
14-16
282
20-22
6-8
41-45
116
58-60
314
7-9
6-8
196
27-30
177
46-50
393
23-25
227
16-18
520
26-30
370
65-67
209
75-80
2-4
421
4-6
6-8
198
40-45
3-5
10-12
415
10-12
14-16
254
26-30
320
51-55
15-17
399
31-35
337
51-55
7-9
31-35
0
1/4
1/2
Miles
0
200
400
800
Meters
N
Mean value of parameter, mg/L
Screen depth (in feet)
NA - No data available
Note: No data available unless noted

Figure 19. Groundwater constituents.- Dissolved Solids

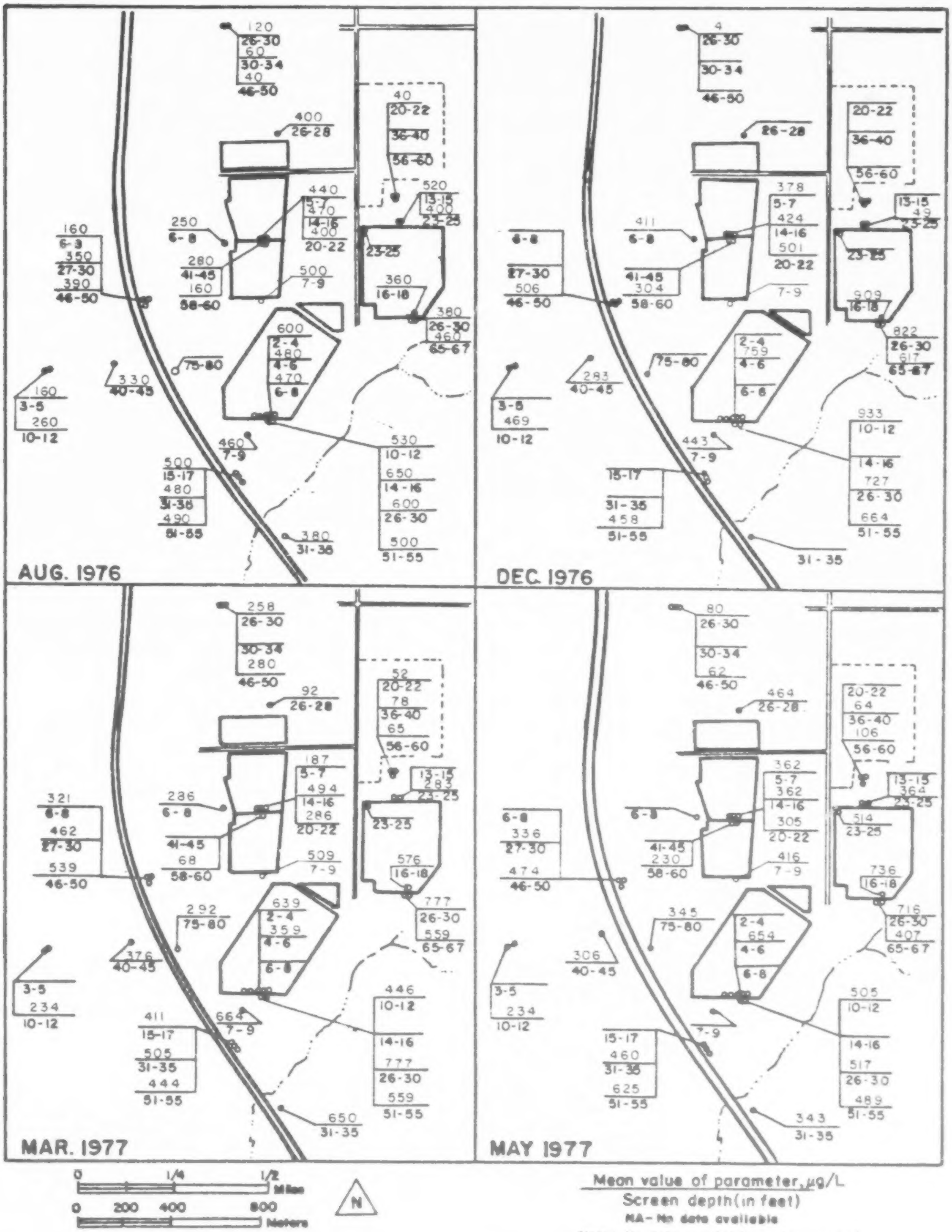

AUG. 1976
DEC. 1976
MAR. 1977
MAY 1977
120
26-30
60
30-34
40
46-50
400
26-28
40
20-22
36-40
56-60
520
13-15
400
23-25
440
5-7
470
14-16
400
20-22
250
6-8
280
41-45
160
58-60
500
7-9
360
16-18
380
26-30
460
65-67
160
6-8
350
27-30
390
46-50
600
2-4
480
4-6
470
6-8
75-80
330
40-45
160
3-5
260
10-12
530
10-12
650
14-16
600
26-30
500
51-55
460
7-9
500
15-17
480
31-35
490
51-55
380
31-35
0 1/4 1/2 Miles
0 200 400 800 Meters
N
Mean value of parameter, μg/L
Screen depth (in feet)
NA- No data available
Note: No data available unless noted

Figure 20. Groundwater constituents.- Boron

### TABLE 17. COMPARISON OF CHLORIDE, TDS, AND BORON APPLIED TO AND PASSING EACH INFILTRATION BASIN

| | Average Parameter Concentration in mg/L | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Basin I | | | Basin II | | | Basin III | | |
| | Cl | TDS | Boron | Cl | TDS | Boron | Cl | TDS | Boron |
| Infiltrated Effluent | 57 | 214 | 0.311 | 77 | 301 | 0.534 | 77 | 301 | 0.534 |
| Immediately Beneath | 27 | 226 | 0.332 | 78 | 381 | 0.593 | 70 | 325 | 0.609 |
| Downgradient | 34 | 194 | 0.381 | 78 | 344 | 0.486 | -- | --- | --- |
| Percent Passing, % | 61 | 91 | 123 | 101 | 115 | 91 | | | |

Although it is probably not justified to attempt to explain the difference between Areas I and II some observations can be made. Some additional idea of the average concentrations infiltrated can be obtained from Table 17. Examination of the average concentrations immediately beneath Basin I would indicate that the average effluent concentrations were probably less than 57 mg/L of chloride and greater than 311 µg/L of boron. If the one low value of 34 µg/L were excluded, the average boron concentration would be 403 µg/L and the boron leaving Area I would be 95 percent compared to the 123 percent indicated in Table 17. The deepest well (42060) included in the average concentrations beneath Basin I is constructed beneath a clay layer of undetermined continuity. This is probably reflected in the lower parameter concentrations for this well which were 22 mg/L chlorides, 101 mg/L dissolved solids, and 191 µg/L boron. Some clay layers were also encountered during construction and subsequent pump testing of Area I downgradient wells. These clay layers may segregate the wastewater plume and complicate the evaluation.

The results downgradient from Basin II are more consistent with what one would expect. Again, the higher concentration of dissolved solids immediately beneath the basin accounts for the higher percentage occurring downgradient.

Soils with organic and clay content generally have small adsorption capacities for boron. For practical purposes, however, chloride, dissolved solids, and boron can be regarded as parameters that are refractory to soil interactions in this environment and thus pass through the infiltration system and subsequent saturated zone relatively unchanged.

The possible landfill contributions of chloride, dissolved solids, and boron concentrations ranged from 1 to 111 mg/L and averaged 51 mg/L, 37 to

292 mg/L and averaged 168 mg/L, and 40 to 106 μg/L and averaged 68 μg/L, respectively. Control groundwater concentrations for chloride, dissolved solids, and boron ranged from 1 to 8 mg/L and averaged 4 mg/L, 23 to 76 mg/L and averaged 40 mg/L, and 4 to 280 μg/L and averaged 113 μg/L, respectively. Thus, only the landfill contribution of chloride and dissolved solids could have detectable influence on the treatment site groundwater. Higher than average chloride concentrations occur in the two deepest landfill monitoring wells, in the deepest well beneath Basin III and in deep well 42400 downgradient from Basin II. The respective average concentrations are 88, 100, and 94 mg/L. The water level contours for December, 1976 (Figure 5, page 14) indicate groundwater flow along this path.

### Potassium, Calcium, Magnesium, and Sodium--

The potassium and calcium concentrations of the applied effluent ranged from 9 to 26 mg/L and 9 to 13 mg/L, respectively. Treatment site groundwater concentrations ranged from 3.5 to 18 mg/L for potassium and from 1 to 80 mg/L for calcium (Figures 21 and 22). These cations along with others such as magnesium and sodium are held in the soil by cation exchange properties of the soil which are properties of the organic and clay content of the soil. Most soils have limited capacity for the univalent potassium and sodium cations and greater capacity for the divalent calcium and magnesium cations.

The potassium and calcium concentrations of the treatment site groundwater are indicators of the ability of the soils to absorb such cations. The resulting concentrations were irregularly variable with period of sampling, distance along path of groundwater travel and with depth.

The average concentrations of potassium, calcium, sodium, and magnesium for the infiltrated effluent, the groundwater beneath the basins and the downgradient groundwater are summarized in Table 18. Examination of the average concentrations of these parameters applied to, immediately beneath, and downgradient indicates that the Vineland and Landis soil infiltration systems have little remaining adsorptive capacity for the monovalent cations, potassium and sodium, but apparently still has downgradient adsorptive capacity for the divalent cations, calcium and magnesium. The capacity for calcium and magnesium appears to have been depleted immediately beneath Basins I and II, but is still available beneath the newer Basin III. Different conclusions could be drawn if the two values of calcium were not deleted from the averages in Table 18.

Groundwater downgradient from the landfill ranged from 0.2 to 2.4 mg/L and averaged 1.4 mg/L for potassium, and from 1.2 to 7.9 mg/L and averaged 3.5 mg/L for calcium. Control groundwater concentrations ranged from <0.5 to 2.9 mg/L and averaged 1.2 mg/L for potassium, and from 0.7 to 4.8 mg/L and averaged 2.7 mg/L for calcium. Magnesium and sodium averaged 2.9 and 40 mg/L, respectively, downgradient from the landfill and 1.0 and 1.8 mg/L, respectively, in the control groundwater. Thus, landfill or control groundwater were not contributing to treatment site groundwater concentrations of potassium, calcium, or magnesium. However, the landfill could be contributing to the sodium concentration.

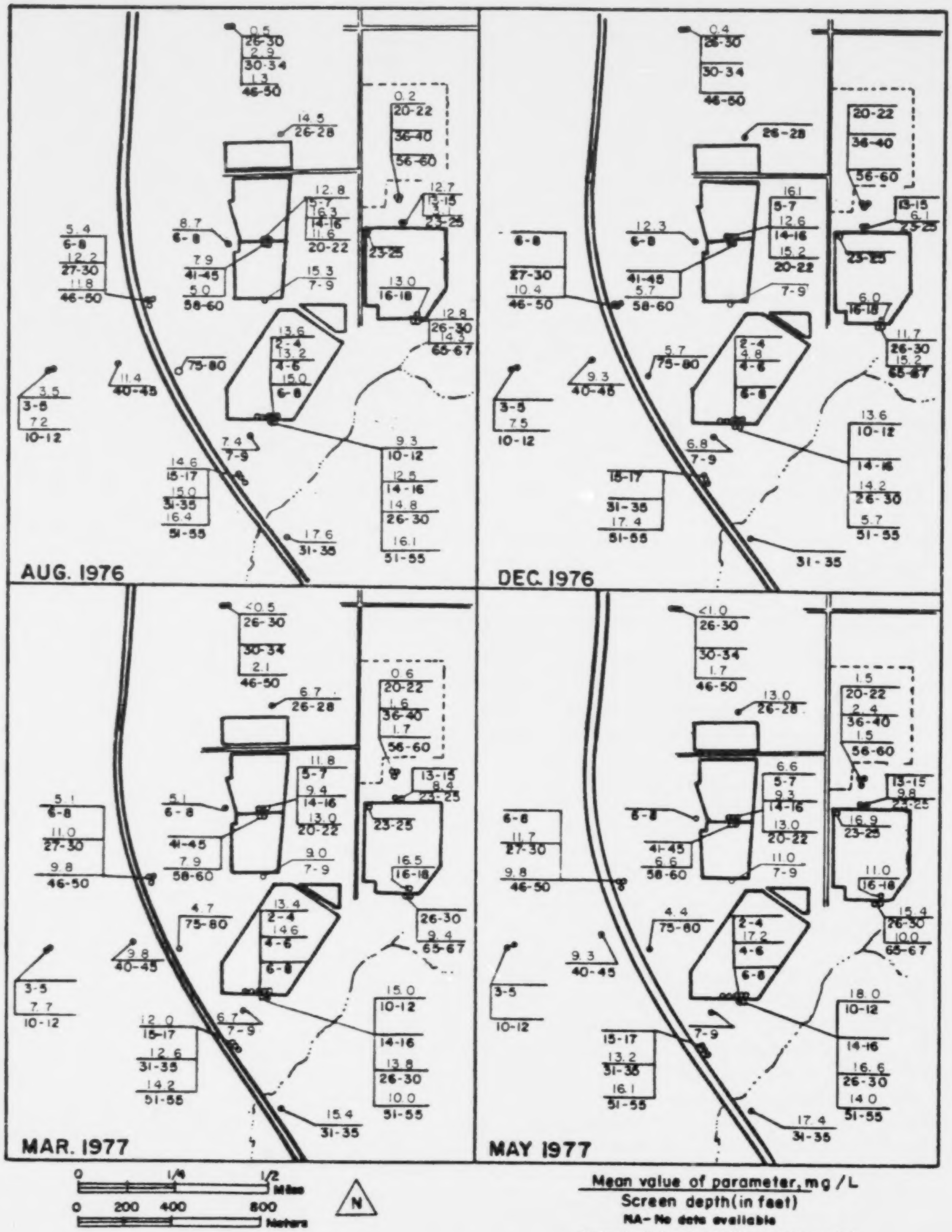

AUG. 1976
DEC. 1976
MAR. 1977
MAY 1977
0 1/4 1/2 Miles
0 200 400 800 Meters
N
Mean value of parameter, mg/L
Screen depth (in feet)
NA- No data available
Note: No data available unless noted

Figure 21. Groundwater constituents.- Potassium

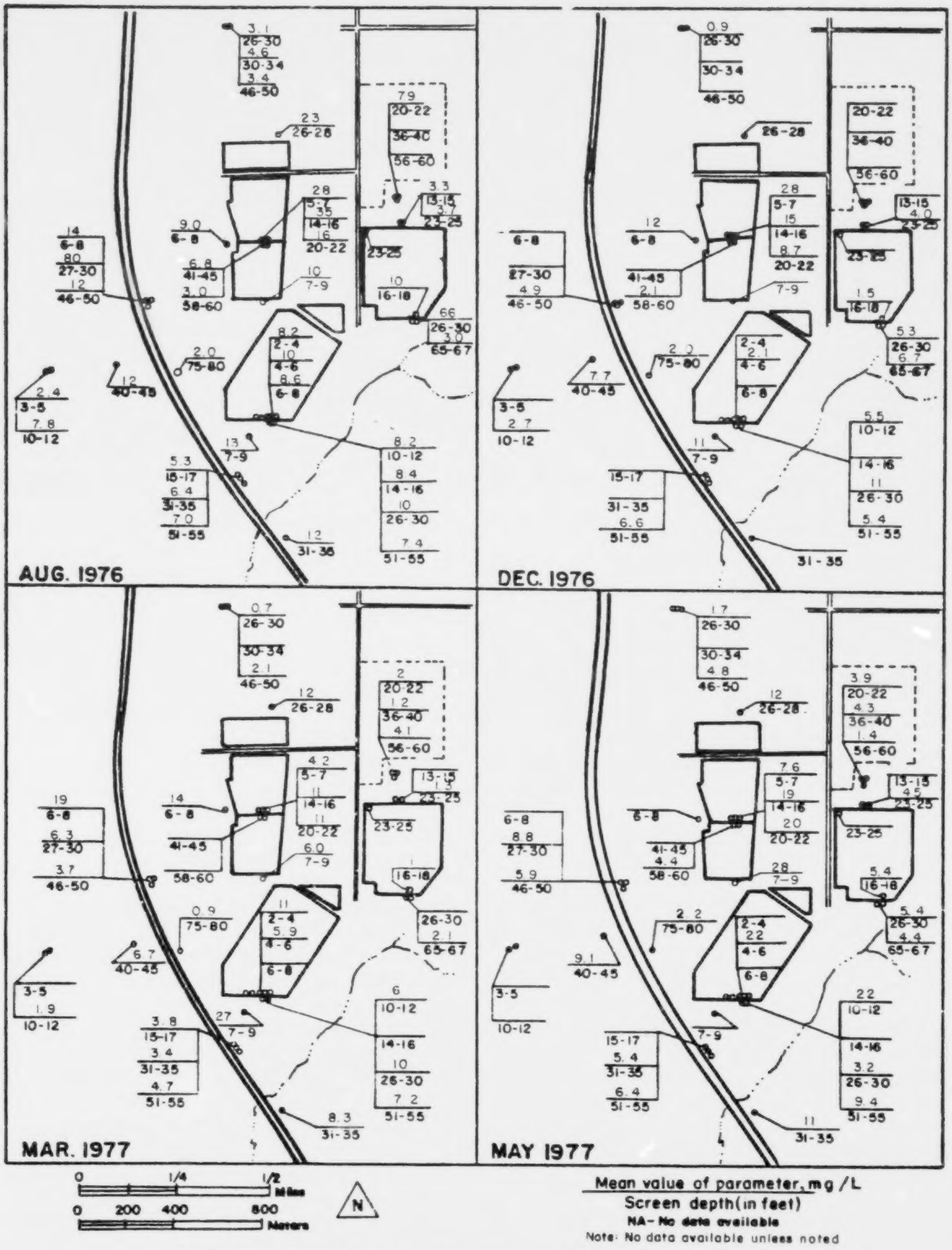

AUG. 1976
DEC. 1976
MAR. 1977
MAY 1977
0
1/4
1/2
Miles
0
200
400
800
Meters
N
Mean value of parameter, mg/L
Screen depth (in feet)
NA- No data available
Note: No data available unless noted

Figure 22. Groundwater constituents.– Calcium

TABLE 18. COMPARISON OF POTASSIUM, CALCIUM, SODIUM, AND MAGNESIUM APPLIED TO AND PASSING EACH INFILTRATION BASIN

| | Average Parameter Concentration in mg/L | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Basin I | | | | Basin II | | | | Basin III | | | |
| | K | Ca | Na | Mg | K | Ca | Na | Mg | K | Ca | Na | Mg |
| Infiltrated Effluent | 14.5 | 11.8 | 60 | 4.1 | 10.4 | 10.8 | 75 | 4.1 | 10.4 | 10.8 | 75 | 4.1 |
| Immediately Beneath | 10.6 | 13.6 | 38 | 5.1 | 13.3 | 8.9 | 101 | 4.1 | 12.0 | 4.5[b] | 86 | 3.0 |
| Downgradient | 9.9 | 6.9[a] | 49 | 4.5 | 14.6 | 4.9 | 100 | 3.7 | | | | |
| Percent Passing, % | 68 | 58 | 82 | 110 | 140 | 45 | 133 | 90 | | | | |

[a] Includes 13 values between 1.9 and 12, but excludes 1 value of 80.

[b] Includes 10 values between 1 and 10, but excludes 1 value of 66.

Phosphorus--

The soluble phosphorus concentration of the applied effluent ranged from 4.5 to 7.2 mg/L. The soluble orthophosphate comprised the majority of soluble phosphorus and ranged in concentration from 3.5 to 6.2 mg/L.

Phosphorus and particularly the soluble orthophosphate are adsorbed on active sites associated with the iron and aluminum content of the acid soils encountered at the Vineland and Landis treatment site. The other soluble phosphorus constituent, soluble organic phosphorus, can be adsorbed on other active sites associated with the clay content of the soil.

The behavior of soluble phosphorus was examined in the treatment site groundwater. The range of concentrations encountered was <0.01 to 7.6 mg/L (Figure 23). The average concentrations immediately beneath and downgradient as determined from the previously selected wells are shown in Table 19.

Groundwater concentrations of soluble phosphorus immediately beneath Basin I varied irregularly with respect to sampling period and with depth to 14 m (46 ft). However, there was a marked decrease in average concentrations in the deepest well which as previously discussed was constructed beneath a clay layer. If well 42060 is omitted from the average concentrations beneath Basin I, the average concentrations of soluble phosphorus and soluble orthophosphate become 2.19 and 1.96 mg/L, respectively, as compared to the lower values shown in Table 19. The adsorption capacity of the soils immediately beneath Basin I have been reduced. Downgradient soils are not yet exhausted and the residual phosphorus concentrations drop rapidly to

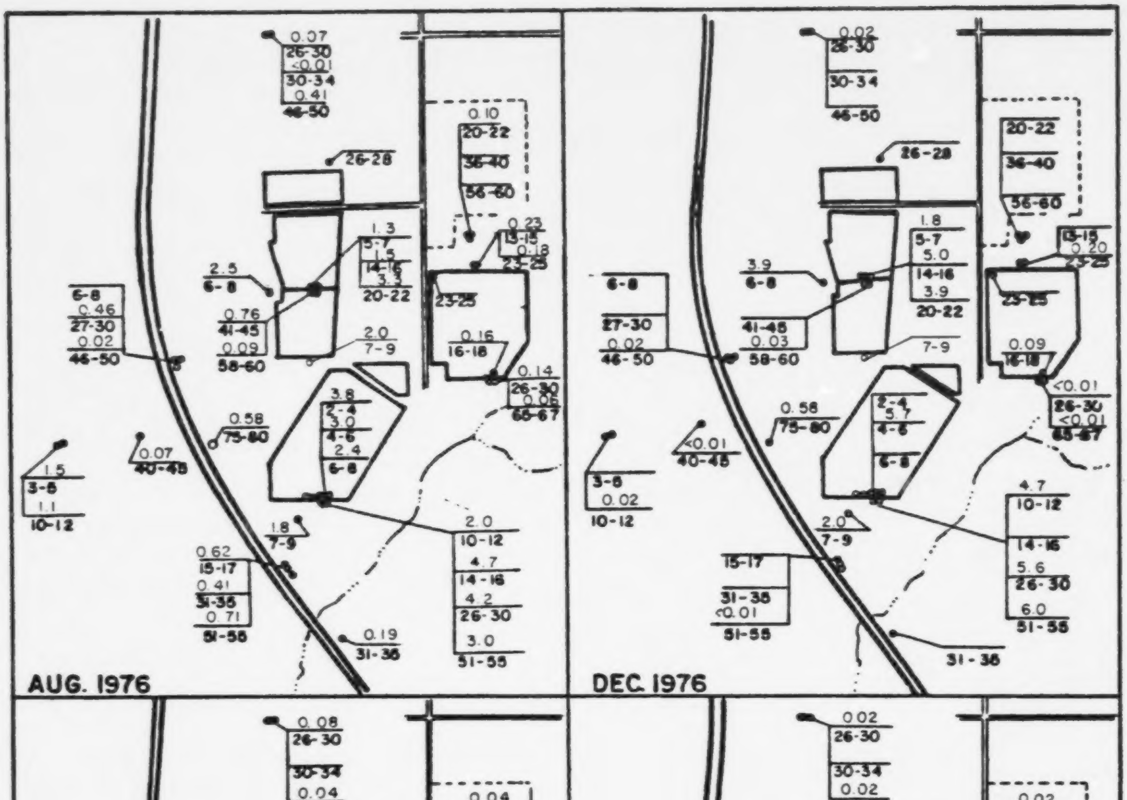

AUG. 1976
0.07
26-30
<0.01
30-34
0.41
46-50
0.10
20-22
36-40
56-60
26-28
1.3
5-7
1.5
14-16
3.3
20-22
0.23
13-15
0.18
23-25
2.5
6-8
6-8
0.46
27-30
0.02
46-50
0.76
41-45
0.09
58-60
23-25
2.0
7-9
0.16
16-18
0.14
26-30
0.06
65-67
3.8
2-4
3.0
4-6
2.4
6-8
0.58
75-80
0.07
40-45
1.5
3-5
1.1
10-12
1.8
7-9
2.0
10-12
4.7
14-16
4.2
26-30
3.0
51-55
0.62
15-17
0.41
31-35
0.71
51-55
0.19
31-35
DEC. 1976
0.02
26-30
30-34
46-50
20-22
36-40
56-60
26-28
1.8
5-7
5.0
14-16
3.9
20-22
13-15
0.20
23-25
3.9
6-8
6-8
27-30
0.02
46-50
41-45
0.03
58-60
23-25
7-9
0.09
16-18
<0.01
26-30
<0.01
65-67
2-4
5.7
4-6
6-8
0.58
75-80
<0.01
40-45
3-5
0.02
10-12
2.0
7-9
4.7
10-12
14-16
5.6
26-30
6.0
51-55
15-17
31-35
<0.01
51-55
31-35
MAR. 1977
0.08
26-30
30-34
0.04
46-50
0.04
20-22
0.05
36-40
0.06
56-60
0.14
26-28
0.32
5-7
0.06
14-16
2.6
20-22
13-15
0.01
23-25
1.7
6-8
0.06
27-30
0.10
46-50
4.4
6-8
41-45
0.09
58-60
23-25
0.69
7-9
0.20
16-18
26-30
0.04
65-67
6.7
2-4
5.5
4-6
6-8
0.33
75-80
0.05
40-45
3-5
0.57
10-12
0.69
7-9
5.8
10-12
14-16
7.1
26-30
3.3
51-55
0.12
15-17
0.25
31-35
0.03
51-55
0.05
31-35
MAY 1977
0.02
26-30
30-34
0.02
46-50
0.02
20-22
0.03
36-40
0.02
56-60
4.4
26-28
0.84
5-7
4.5
14-16
2.6
20-22
13-15
0.02
23-25
6-8
6-8
0.04
27-30
0.03
46-50
41-45
0.04
58-60
0.04
23-25
0.27
7-9
0.26
16-18
0.04
26-30
0.02
65-67
0.26
75-80
2-4
2.9
4-6
6-8
0.03
40-45
3-5
10-12
7-9
4.0
10-12
14-16
7.6
26-30
2.2
51-55
15-17
0.26
31-35
0.02
51-55
0.02
31-35
0
1/4
1/2
Miles
0
200
400
800
Meters
N
Mean value of parameter, mg/L
Screen depth (in feet)
NA- No data available
Note: No data available unless noted.

Figure 23. Groundwater constituents.- Soluble Phosphorus

TABLE 19. COMPARISON OF SOLUBLE PHOSPHORUS AND SOLUBLE ORTHOPHOSPHATE APPLIED TO AND PASSING EACH INFILTRATION BASIN

| | Average Parameter Concentration in mg/L | | | | | |
|---|---|---|---|---|---|---|
| | Basin I | | Basin II | | Basin III | |
| | P | $PO_4$ | P | $PO_4$ | P | $PO_4$ |
| Infiltrated Effluent | 5.7 | 4.8 | 6.3 | 4.8 | 6.3 | 4.8 |
| Immediately Beneath | 1.69 | 1.54 | 4.51 | 3.80 | 0.09 | 0.07 |
| Downgradient | 0.18 | <0.03 | 0.27 | 0.11 | | |
| Percent Passing, % | 3.2 | 0.6 | 4.3 | 2.3 | | |

the 0.1 mg/L range with distance along the path of groundwater travel.

The soils beneath Basin II appear to be almost exhausted for further phosphorus adsorption under present operating conditions. By contrast, the relatively new Landis Basin III site produced consistent concentrations immediately beneath in the range of 0.1 mg/L. The Basin III groundwater also exhibited a regular soluble phosphorus gradient with depth which would be expected for an active site.

The average soluble phosphorus concentration downgradient from Basin II was 0.27 mg/L. The weighted average soluble phosphorus concentration of the applied effluent was 6.3 mg/L and therefore, the estimated passage of soluble phosphorus was 4.3 percent. Approximately 2.3 percent of the applied soluble orthophosphate was passing the downgradient wells. This residual concentration would be further reduced by contact with soils downgradient from the area monitored for this study until residual phosphorus was in equilibrium with the area soils at background concentrations.

Soluble phosphorus contributions to the treatment site groundwater from the landfill ranged from 0.02 to 0.10 mg/L and averaged 0.03 mg/L. Soluble phosphorus concentrations contributed by control groundwater ranged from <0.01 to 0.41 mg/L and averaged 0.08 mg/L. Thus, no significant phosphorus contribution to the treatment groundwater was observed to originate at the landfill and background concentrations of soluble phosphorus did not markedly affect treatment site groundwater quality.

Metals--

Groundwater was examined for the presence of the following metals:

arsenic, cadmium, cobalt, chromium, copper, iron, lead, maganese, mercury, nickel, selenium, and zinc. The concentrations of cadmium, cobalt, chromium, lead, mercury, nickel, copper, selenium, and arsenic were generally at or below minimum detectable levels.

Iron, manganese, and zinc had perceptible concentrations in the groundwater tributary to the treatment site. Figures 24 and 25 depict the monitoring results for iron and zinc, respectively. The behavior of manganese in the treatment site groundwater was similar to that of iron.

The average concentrations of iron, manganese, and zinc in the effluent, immediately beneath, and downgradient from the infiltration basins are summarized in Table 20.

TABLE 20. COMPARISON OF IRON, MANGANESE, AND ZINC APPLIED TO AND PASSING EACH INFILTRATION BASIN

| | Average Parameter Concentration in mg/L | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Basin I | | | Basin II | | | Basin III | | |
| | Fe | Mn | Zn[a] | Fe | Mn | Zn[a] | Fe | Mn | Zn[a] |
| Infiltrated Effluent | 1.5 | 0.06 | 0.127 | 1.2 | 0.07 | 0.121 | 1.2 | 0.07 | 0.121 |
| Immediately Beneath | 12.6 | 0.13 | 0.024[b] | 9.0 | 0.09 | 0.043 | 29.3 | 0.53 | 0.043 |
| Downgradient | 42.7 | 0.40 | 0.039 | 33.6 | 0.32 | 0.029 | | | |

[a] Includes several values less than the detectable limit of 0.02 mg/L.

[b] Excludes well 42080 with an average concentration of 2.18 mg/L. If included, average would be 0.525 mg/L.

Iron and manganese concentrations in the treatment site groundwater generally increase in concentration with depth and markedly increase downgradient. The statistical comparison found that these were the only two parameters which increased downgradient. The possible sources for the extraordinarily high iron concentrations are groundwater contributions from the upgradient landfill and/or the iron content of the treatment site soil.

Iron and manganese concentrations averaged <1.6 mg/L and <0.15 mg/L, respectively, at the control wells and 0.26 mg/L and 0.21 mg/L, respectively, at the wells downgradient from the landfill. There is apparently no signicant iron or manganese contribution from the control groundwater or the landfill.

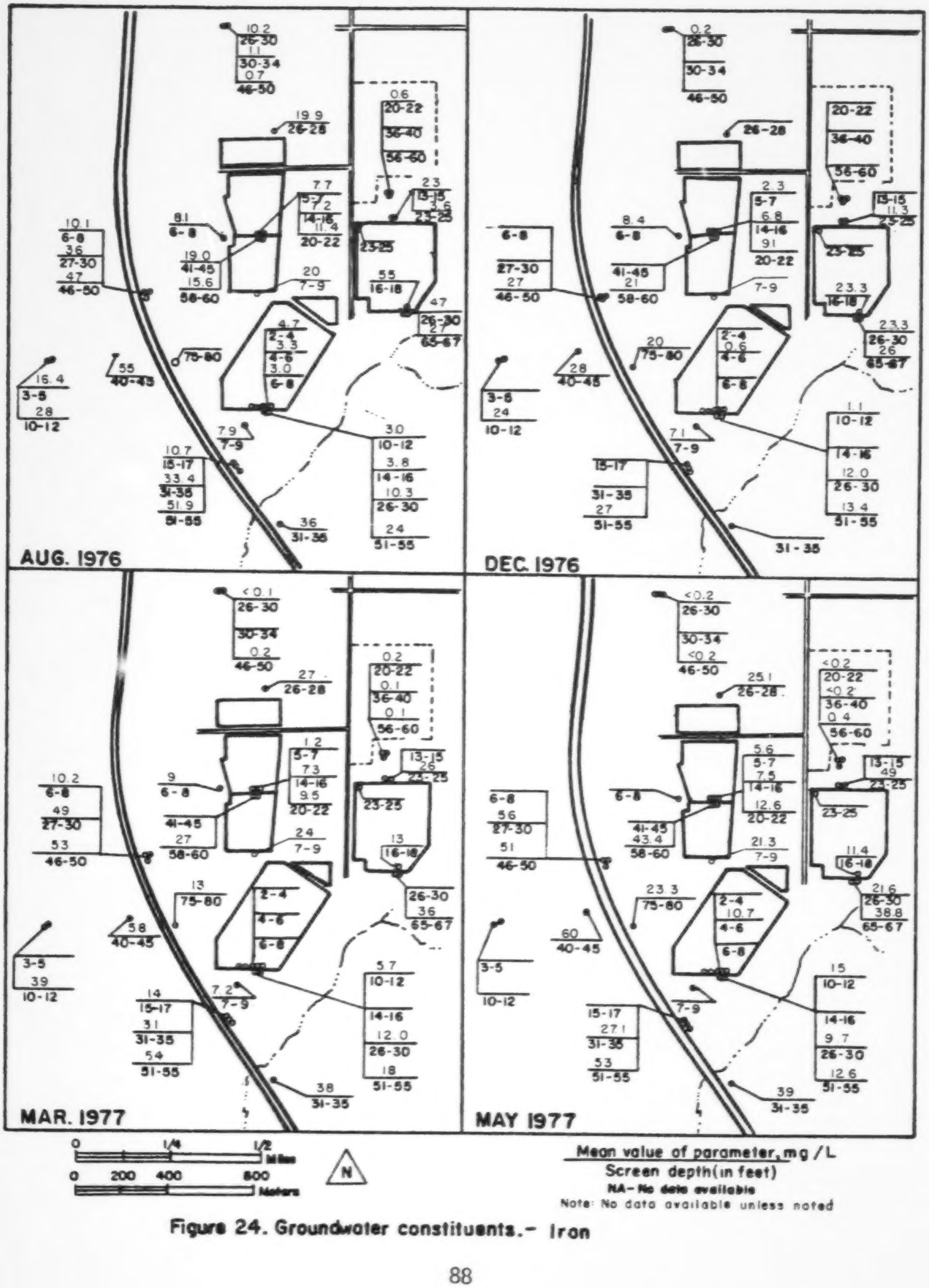

AUG. 1976
DEC. 1976
MAR. 1977
MAY 1977
0
1/4
1/2
Miles
0
200
400
800
Meters
N
Mean value of parameter, mg / L
Screen depth (in feet)
NA- No data available
Note: No data available unless noted

Figure 24. Groundwater constituents.- Iron

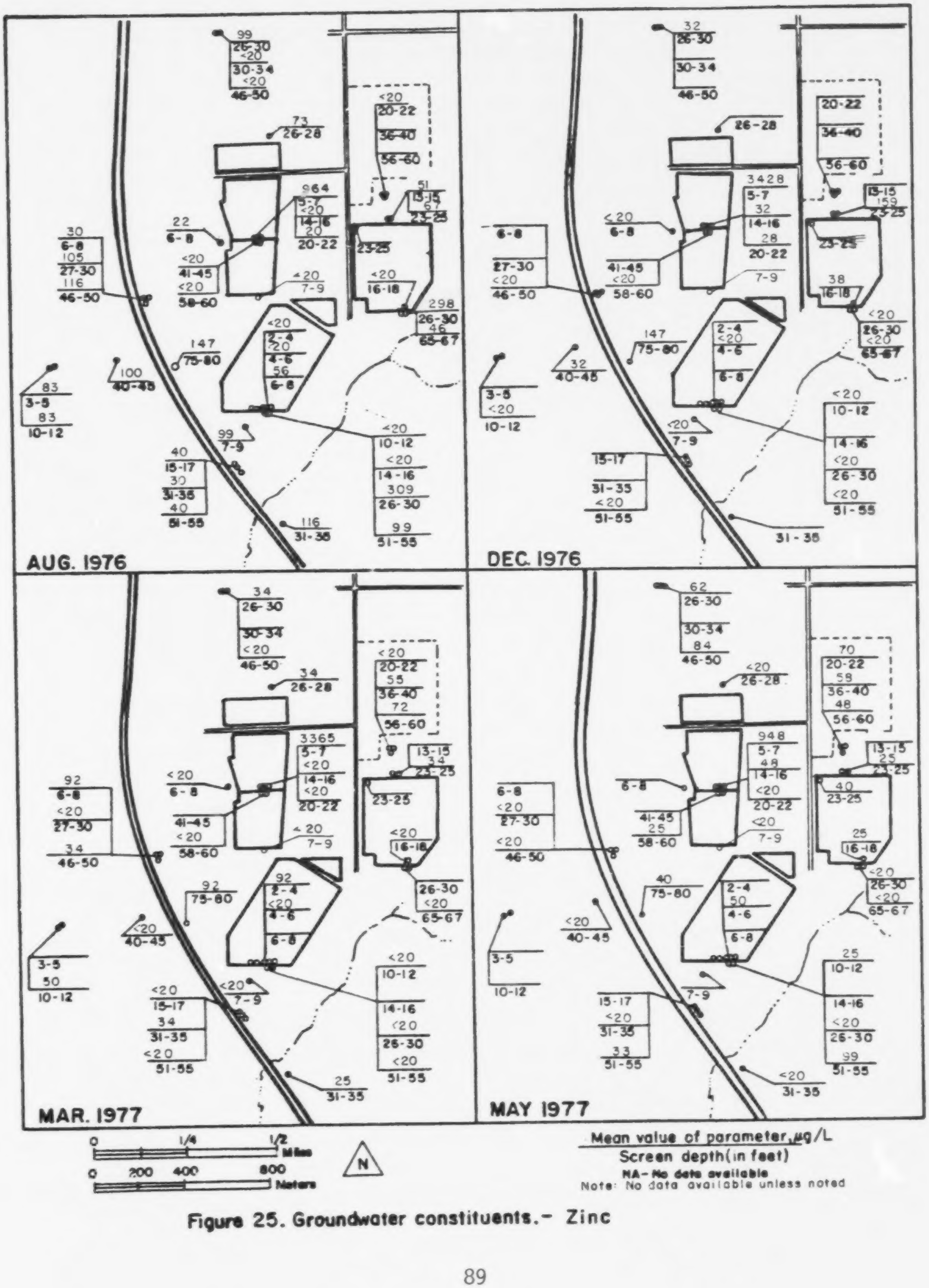

AUG. 1976
DEC. 1976
MAR. 1977
MAY 1977
0
1/4
1/2
Miles
0
200
400
800
Meters
N
Mean value of parameter, µg/L
Screen depth (in feet)
NA- No data available
Note: No data available unless noted

Figure 25. Groundwater constituents.- Zinc

An examination of Figure 34 (page 112) under the discussion of soils shows that iron has apparently been leached from the soils under Basins I and II when compared to nearby control soils. Conversely, leaching is not evident at Basin III which has only been in operation since 1974. The average iron concentration (Table 20) of the groundwater beneath the respective basins would also indicate that the soils beneath Basins I and II have been sufficiently depleted so that less iron is now being leached as compared to the higher concentration immediately beneath Basin III where very little depletion has occurred to date. The extremely high downgradient concentrations indicate that iron is still being leached as the water moves through the downgradient soils. Manganese concentrations follow the same pattern as iron. The mechanism for this is likely the reduction in an anaerobic environment of the oxidized hydroxides to the soluble ferrous and manganous forms and/or chelation by the organic constituents remaining in the water. The average iron discharge concentration from the monitored study site is 43 mg/L downgradient from Basin I and 34 mg/L downgradient from Basin II. Iron concentrations greater than 0.3 mg/L can be expected to cause nuisance problems in water supply use (USEPA, 1976).

An approximate iron balance attempted under the soils discussion adds additional validity to the conclusion that iron and manganese are leaching from the soils.

The zinc concentration in the control groundwater ranged from <20 to 99 μg/L and averaged 46 μg/L. The zinc concentrations downgradient from the landfill ranged from <20 to 72 μg/L and averaged 46 μg/L, which indicated no contribution from the landfill to the background concentration found in the control wells.

The data in Table 20 and Figure 25 show that in passing through the infiltration basins, the zinc concentration quickly reach background levels even in the shallowest wells. Figure 32 (page 110) in the soils discussion verifies a significant accumulation of zinc in the soils beneath each basin and particularly within the first 0 to 30 cm (0 to 1 ft).

Extremely high values of zinc ranging from 948 to 3428 and averaging 2176 μg/L were found in well 42080. This is a shallow well 1.5 to 2 m (5 to 7 ft) deep constructed just at the top of the water table beneath Basin I. It is probably significant that the average concentration of nickel in this well was 173 μg/L as compared to values consistently less than detectable limits of 100 μg/L for all other wells. A similar pattern was evident with copper. Higher concentrations might be expected in nearby wells; however, the high zinc values did not occur in adjacent well 42090 which is only 2.8 m (9 ft) deeper than well 42080 or in the nearest downgradient well 42260 which is 1.8 to 2.4 m ( 6 to 8 ft) deep. For the potential groundwater flow rate of 1 to 2.5 m (3.5 to 8 ft) per day and the sampling time frame, groundwater should move from Basin I to downgradient well 42260 but might not reach further downgradient wells 42280 and 42290. The groundwater contours for December, 1976, (Figure 5, page 14) show that flow from well 42080 could move around well 42260. It is also possible that the high zinc concentration would be removed by the soils before the groundwater reached any of the downgradient wells.

One possibility is that a slug of wastewater containing high concentrations of metals was infiltrated into the same or an adjacent pit where well 42080 is located. The zinc concentrations of 964, 3428, 3365, and 948 µg/L for the four sampling rounds suggest the passage of a slug of contaminated water. However, the duration is not consistent with a small slug unless some adsorption and leaching or flushing are also occurring at the fluctuating interface of the saturated zone. Another possibility is that sludge or even some metal object has been disposed near well 42080 in the past.

Pesticides and Herbicides--

Test site groundwaters were examined for the presence of endrin, lindane, methoxychlor, toxaphene, 2,4-D and 2,4,5 TP Silvex. Endrin, methoxychlor, and toxaphene were not found above the respective detectable limits of <0.03, <0.01 , and <0.1 ng/L.

The herbicides 2,4-D and 2,4,5 TP Silvex were found at concentrations in the same range as encountered in the control groundwater and at concentrations well below problem levels.

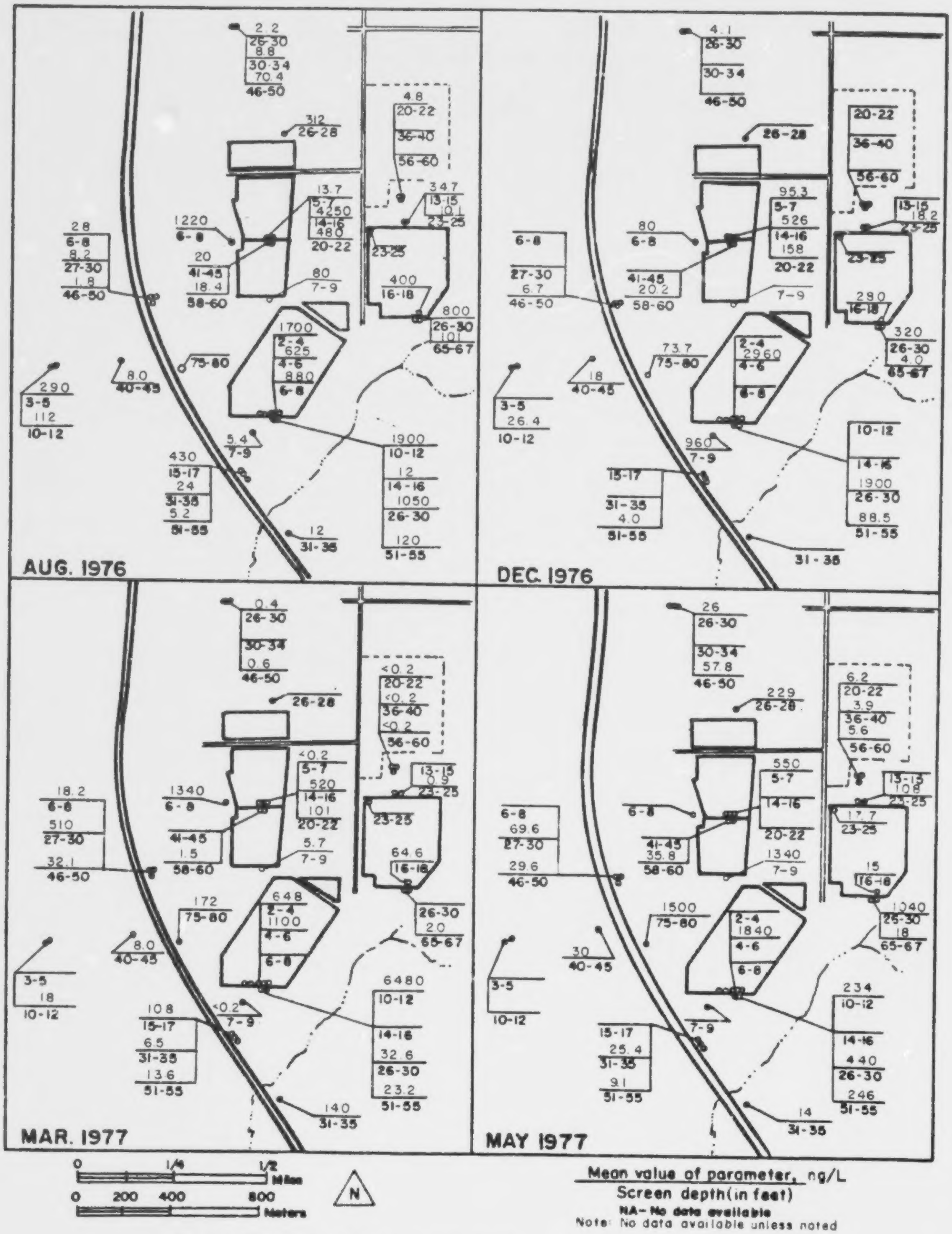
The lindane concentration in the applied effluent ranged from 0.5 to 10,300 ng/L with the higher values occurring in August, 1976. The lindane concentration observed in the treatment site groundwater ranged from <0.2 to 6,480 ng/L and decreased with distance of travel along the direction of groundwater flow (Figure 26). There was no discerning gradient with depth except that high values did not occur in the deepest wells beneath the basins.

At Basin I the average concentration of the applied effluent was 2830 ng/L and the average concentration beneath the basin was 484 ng/L. This includes the average concentration of the deepest well which was only 18.6 ng/L or near background levels. The previously selected downgradient wells averaged 62.8 ng/L.

Effluent concentrations at Basins II and III averaged 1227 ng/L as compared to average concentrations beneath the basins of 1172 ng/L and 227 ng/L, respectively. Again, the deepest wells were considerably lower, averaging 119 ng/L beneath Basin II and 31 ng/L or near background levels beneath Basin III.

The higher loading rates and higher water table at Basin II are apparently resulting in higher concentrations getting to the shallow and intermediate wells immediately beneath the basin as compared to the other two basins. However, the average downgradient concentration of 69.5 ng/L is about the same as Basin I downgradient wells and indicates continued reduction with travel.

The lindane concentration in the landfill groundwater ranged from <0.2 to 6.2 ng/L and averaged 3 ng/L. The control groundwater ranged from 0.4 to 70.4 ng/L and averaged 21 ng/L and could have contributed to the test site groundwater concentrations. Lindane concentration of the test site groundwater decreased with depth and movement downgradient. The National Interim Primary Drinking Water Regulations standard maximum contaminant level for


AUG. 1976
2.2
26-30
8.8
30-34
70.4
46-50
312
26-28
4.8
20-22
36-40
56-60
347
13-15
10.1
23-25
13.7
5-7
4250
14-16
480
20-22
1220
6-8
20
41-45
18.4
58-60
80
7-9
23-25
400
16-18
800
26-30
101
65-67
28
6-8
8.2
27-30
1.8
46-50
1700
2-4
625
4-6
880
6-8
75-80
290
3-5
112
10-12
8.0
40-45
5.4
7-9
430
15-17
24
31-35
5.2
51-55
1900
10-12
12
14-16
1050
26-30
120
51-55
12
31-35
DEC. 1976
4.1
26-30
30-34
46-50
26-28
20-22
36-40
56-60
95.3
5-7
526
14-16
158
20-22
13-15
18.2
23-25
80
6-8
23-25
6-8
27-30
6.7
46-50
41-45
20.2
58-60
7-9
290
16-18
320
26-30
4.0
65-67
2-4
2960
4-6
6-8
73.7
75-80
18
40-45
3-5
26.4
10-12
960
7-9
10-12
14-16
1900
26-30
88.5
51-55
15-17
31-35
4.0
51-55
31-35
MAR. 1977
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26-30
30-34
0.6
46-50
26-28
<0.2
20-22
<0.2
36-40
<0.2
56-60
<0.2
5-7
520
14-16
101
20-22
13-15
0.9
23-25
1340
6-8
23-25
18.2
6-8
510
27-30
32.1
46-50
41-45
1.5
58-60
5.7
7-9
64.6
16-18
648
2-4
1100
4-6
6-8
26-30
2.0
65-67
172
75-80
8.0
40-45
3-5
18
10-12
6480
10-12
14-16
32.6
26-30
23.2
51-55
108
15-17
6.5
31-35
13.6
51-55
<0.2
7-9
140
31-35
MAY 1977
26
26-30
30-34
57.8
46-50
229
26-28
6.2
20-22
3.9
36-40
5.6
56-60
550
5-7
14-16
20-22
13-15
108
23-25
6-8
17.7
23-25
6-8
69.6
27-30
29.6
46-50
41-45
35.8
58-60
1340
7-9
15
16-18
1040
25-30
18
65-67
1500
75-80
2-4
1840
4-6
6-8
30
40-45
3-5
10-12
234
10-12
14-16
440
26-30
246
51-55
15-17
25.4
31-35
9.1
51-55
7-9
14
31-35
0
1/4
1/2
Miles
0
200
400
800
Meters
N
Mean value of parameter, ng/L
Screen depth (in feet)
NA- No data available
Note: No data available unless noted

Figure 26. Groundwater constituents.- Lindane

lindane is 4,000 ng/L (USEPA, 1976). The minor concentrations leaving the areas are not of significant concern.

Coliform Bacteria--

Total and fecal coliform results are shown on Figures 27 and 28, respectively. These evaluations used the data from all wells rather than those designated in the previous analyses. Despite taking all precautions, some contamination during the field sampling may be responsible for the scattered positive total coliform counts in some of the wells not located beneath or adjacent to the basins. This should be considered when evaluating the data.

Positive counts for total coliform occurred in two of eight control well samples and two of seven landfill well samples.

Positive total coliform counts were consistently found directly beneath all three basins. Often the results were too numerous to count. Beneath the basins, positive total coliform counts were found at all monitoring depths. For wells downgradient from Basin II the total coliform counts were significantly less than directly below Basin II with only two samples yielding positive results. With the exception of the August, 1976, sampling, the same trend occurred for wells downgradient from Basin I. During the August, 1976, sampling round, however, two samples from wells downgradient from Basin I yielded results for total coliform too numerous to count. High values occurring only on the first round suggested contamination from construction.

In contrast, positive fecal coliform counts which are more a reliable indicator of fecal contamination were restricted to the shallower well depths directly beneath the basins. Only three samples exhibited positive fecal coliform counts of 183, 300 and 4/100 mL for depths greater than 6 m (20 ft) beneath the basins. No fecal coliforms were found at depths below 9 m (30 ft).

For wells downgradient from Basins I and II, no positive fecal coliform counts occurred. One positive fecal coliform count (69/100 mL) was monitored during March, 1977, for intermediate well number 42370 which is approximately 50 m (165 ft) from Basin II and 2.1 to 2.7 m (7 to 9 ft) deep.

The obviously decreasing magnitude of total coliform with depth and with movement away from the basins and the absence of positive fecal coliform counts in any well deeper than 12 m (40 ft) or further than 50 m (165 ft) downgradient illustrates the capability of the sands to limit significant movement of the infiltrated coliform.

Viruses--

The control site wells tested negative for infectious viruses on all four sampling rounds. The primary treatment plant effluent tested positive for virus particles on all four sampling rounds ranging from 120 to 4659 infectious virus units per 100 L of wastewater (Table 21).

On the first sampling round, August, 1976, viruses were found in 9 of 10 test wells beneath Basins I and II at depths varying from 0.6 to 16.8 m

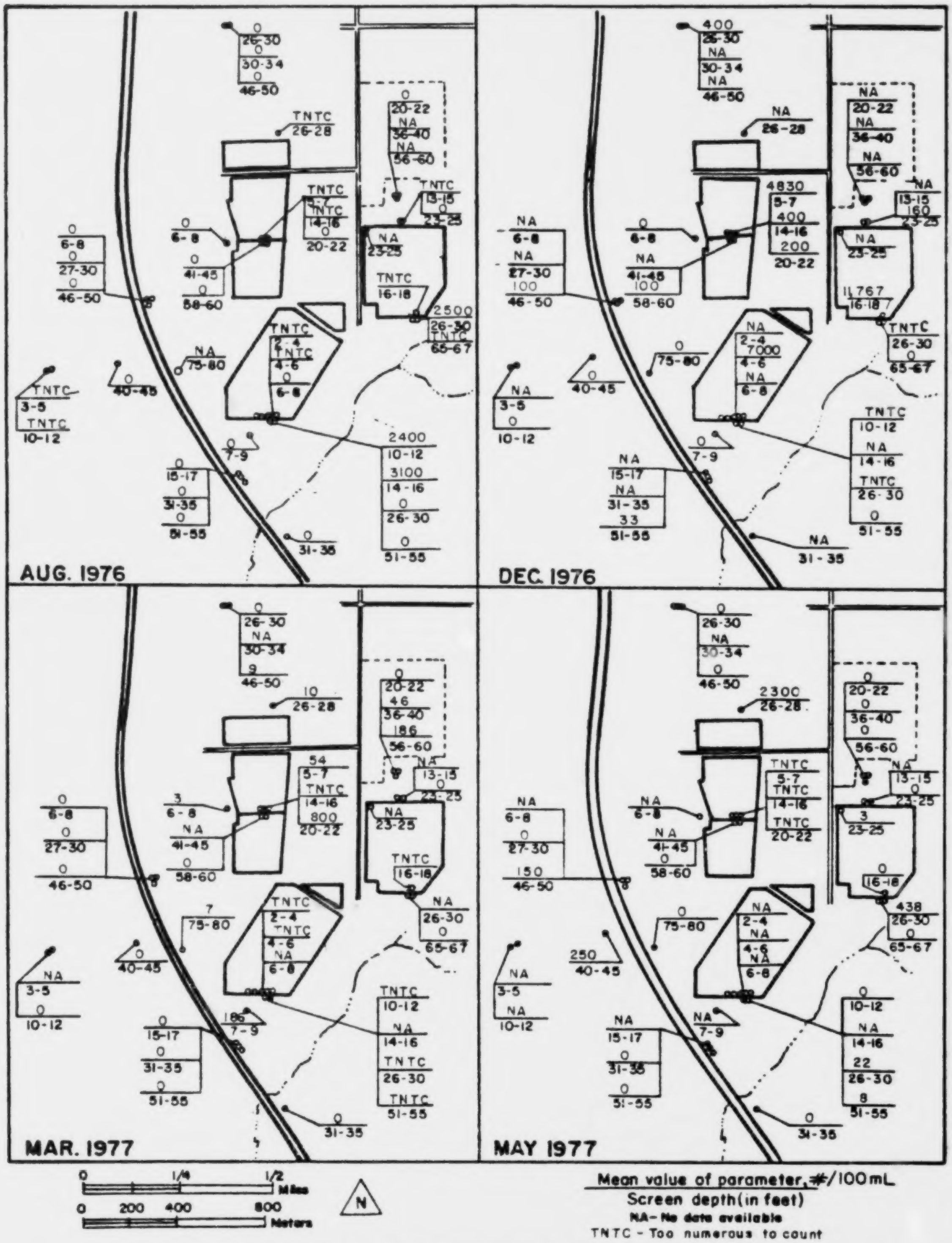

AUG. 1976
0
26-30
0
30-34
0
46-50
TNTC
26-28
0
20-22
NA
36-40
NA
56-60
TNTC
5-7
TNTC
14-16
0
20-22
TNTC
13-15
0
23-25
0
6-8
0
41-45
0
58-60
NA
23-25
TNTC
16-18
2500
26-30
TNTC
65-67
0
6-8
0
27-30
0
46-50
TNTC
2-4
TNTC
4-6
0
6-8
NA
75-80
0
40-45
TNTC
3-5
TNTC
10-12
0
7-9
2400
10-12
3100
14-16
0
26-30
0
51-55
0
15-17
0
31-35
0
51-55
0
31-35
DEC. 1976
400
26-30
NA
30-34
NA
46-50
NA
26-28
NA
20-22
NA
36-40
NA
56-60
4830
5-7
400
14-16
200
20-22
NA
13-15
160
23-25
0
6-8
NA
41-45
100
58-60
NA
23-25
11,767
16-18
TNTC
26-30
0
65-67
NA
6-8
NA
27-30
100
46-50
NA
2-4
7000
4-6
NA
6-8
0
75-80
0
40-45
NA
3-5
0
10-12
0
7-9
TNTC
10-12
NA
14-16
TNTC
26-30
0
51-55
NA
15-17
NA
31-35
33
51-55
NA
31-35
MAR. 1977
0
26-30
NA
30-34
9
46-50
10
26-28
0
20-22
46
36-40
186
56-60
54
5-7
TNTC
14-16
800
20-22
NA
13-15
0
23-25
3
6-8
NA
41-45
0
58-60
NA
23-25
TNTC
16-18
NA
26-30
0
65-67
0
6-8
0
27-30
0
46-50
TNTC
2-4
TNTC
4-6
NA
6-8
7
75-80
0
40-45
NA
3-5
0
10-12
186
7-9
TNTC
10-12
NA
14-16
TNTC
26-30
TNTC
51-55
0
15-17
0
31-35
0
51-55
0
31-35
MAY 1977
0
26-30
NA
30-34
0
46-50
2300
26-28
0
20-22
0
36-40
0
56-60
TNTC
5-7
TNTC
14-16
TNTC
20-22
NA
13-15
0
23-25
NA
6-8
NA
41-45
0
58-60
3
23-25
0
16-18
438
26-30
0
65-67
NA
6-8
0
27-30
150
46-50
NA
2-4
NA
4-6
NA
6-8
0
75-80
250
40-45
NA
3-5
NA
10-12
NA
7-9
0
10-12
NA
14-16
22
26-30
8
51-55
NA
15-17
0
31-35
0
51-55
0
31-35
0
1/4
1/2
Miles
0
200
400
800
Meters
N
Mean value of parameter, #/100 mL
Screen depth (in feet)
NA - No data available
TNTC - Too numerous to count

Figure 27. Groundwater constituents.- Total coliform.

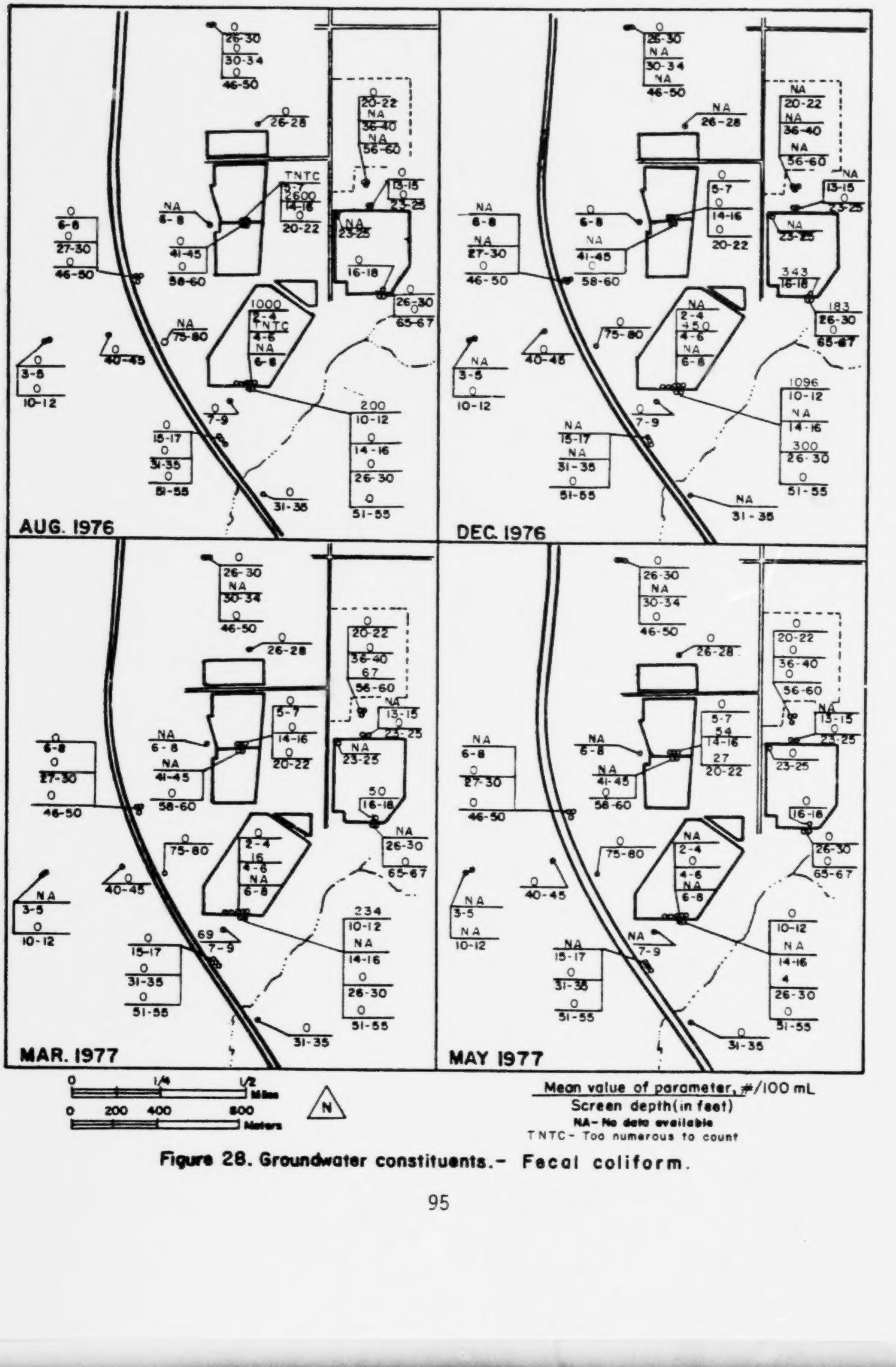

AUG. 1976
DEC. 1976
MAR. 1977
MAY 1977
0
1/4
1/2
Miles
0
200
400
800
Meters
N
Mean value of parameter, #/100 mL
Screen depth(in feet)
NA- No data available
TNTC- Too numerous to count

Figure 28. Groundwater constituents.- Fecal coliform.

TABLE 21. VIRUS ISOLATION

| Source Sample No. | Depth Screened (m) | Date Sampled | Original Volume of Sample (L) | Volume of Concentrate[a] (mL) | Infectious Virus Units per 100 mL of Concentrate BGM[b] | Infectious Virus Units per 100 mL of Concentrate PB[c] | Infectious Virus Units per 100 L of Sample BGM | Infectious Virus Units per 100 L of Sample PB |
|---|---|---|---|---|---|---|---|---|
| Control Site Wells | | | | | | | | |
| 410301 | 7.9-9.1 | 8-29-76 | 273 | 50 | 0 | -- | 0 | -- |
| 410302 | | 12-13-76 | 151 | 33 | 0 | -- | 0 | -- |
| 410303 | | 3-12-77 | 132 | 33 | 0 | 0 | 0 | 0 |
| 410304 | | 5-26-77 | 151 | 29 | 0 | -- | 0 | -- |
| PTP Effluent | | | | | | | | |
| 425501 | NA | 8-30-76 | 68 | 66 | 4800 | -- | 4659 | -- |
| 425502 | | 12-16-76 | 57 | 33 | 333 | -- | 193 | -- |
| 425503 | | 3-07-77 | 30 | 66 | 100 | 200 | 220 | 440 |
| 425504 | | 5-30-77 | 68 | 74 | 110 | -- | 120 | -- |
| Test Site Wells | | | | | | | | |
| Area I | | | | | | | | |
| 420801 | 1.5-2.1 | 8-29-76 | 167 | 182 | 1267 | -- | 1381 | -- |
| 420803 | | 3-07-77 | 108 | 83 | 0 | 0 | 0 | 0 |
| 420901 | 4.3-4.9 | 8-30-76 | 151 | 110 | 50 | -- | 36 | -- |
| 420902 | | 12-14-76 | 79 | 99 | 0 | -- | 0 | -- |
| 420903 | | 3-12-77 | 76 | 99 | 0 | 0 | 0 | 0 |
| 420904 | | 5-31-77 | 87 | 55 | 0 | -- | 0 | -- |
| 421001 | 6.1-6-7 | 8-29-76 | 151 | 83 | 35 | -- | 19 | -- |
| 421002 | | 12-14-76 | 114 | 66 | 0 | -- | 0 | -- |
| 421003 | | 3-12-77 | 76 | 94 | 0 | 0 | 0 | 0 |
| 421004 | | 5-31-77 | 132 | 66 | 0 | -- | 0 | -- |
| Area II | | | | | | | | |
| 421701 | 0.6-1.2 | 8-27-76 | 265 | 61 | 7 | -- | 2 | -- |
| 421702 | | 12-16-76 | 64 | 88 | 0 | -- | 0 | -- |
| 421703 | | 3-09-77 | 106 | 107 | 0 | 0 | 0 | 0 |
| 421704 | | 5-31-77 | 87 | 94 | 0 | -- | 0 | -- |
| 421801 | 1.2-1.8 | 8-27-76 | 174 | 44 | 15 | -- | 4 | -- |
| 421802 | | 12-15-76 | 83 | 55 | 25 | -- | 17 | -- |
| 421803 | | 3-09-77 | 121 | 44 | 0 | 0 | 0 | 0 |
| 421804 | | 5-30-77 | 68 | 64 | 0 | -- | 0 | -- |
| 420401 | 1.8-2.4 | 8-28-76 | 250 | 66 | 24 | -- | 6 | -- |
| 420402 | | 12-25-76 | 102 | 44 | 0 | -- | 0 | -- |
| 420403 | | 3-11-77 | 76 | 66 | 0 | 0 | 0 | 0 |
| 420404 | | 5-30-77 | 102 | 58 | 0 | -- | 0 | -- |

(Continued)

Table 21. Continued

| Source Sample No. | Depth Screened (m) | Date Sampled | Original Volume of Sample (L) | Volume of Concentrate[a] (mL) | Infectious Virus Units per 100 mL of Concentrate BGM[b] | Infectious Virus Units per 100 mL of Concentrate PB[c] | Infectious Virus Units per 100 L of Sample BGM | Infectious Virus Units per 100 L of Sample PB |
|---|---|---|---|---|---|---|---|---|
| 421901 | 2.9-3.5 | 8-28-76 | 125 | 77 | 0 | -- | 0 | -- |
| 421902 | | 12-15-76 | 79 | 44 | 0 | -- | 0 | -- |
| 421903 | | 3-08-77 | 76 | 66 | 90 | 0 | 78 | 0 |
| 421904 | | 5-29-77 | 98 | 108 | 0 | -- | 0 | -- |
| 422001 | 4.3-4.9 | 8-25-76 | 265 | 193 | 8 | -- | 6 | -- |
| 422002 | | 12-14-76 | 95 | 110 | 0 | -- | 0 | -- |
| 422003 | | 3-11-77 | 76 | 72 | 0 | 0 | 0 | 0 |
| 422004 | | 5-29-77 | 83 | 72 | 0 | -- | 0 | -- |
| 420301 | 7.9-9.1 | 8-30-76 | 235 | 121 | 13 | -- | 7 | -- |
| 420302 | | 12-12-76 | 76 | 50 | 0 | -- | 0 | -- |
| 420303 | | 3-10-77 | 106 | 44 | 40 | 0 | 17 | 0 |
| 420304 | | 5-27-77 | 61 | 99 | 0 | -- | 0 | -- |
| 422101 | 15.5-16.8 | 8-29-76 | 182 | 110 | 4 | -- | 2 | -- |
| 422102 | | 12-11-76 | 114 | 330 | 0 | -- | 0 | -- |
| 422103 | | 3-11-77 | 76 | 66 | 0 | 0 | 0 | 0 |
| 422104 | | 5-27-77 | 57 | 53 | 0 | -- | 0 | -- |
| Downgradient from Area II | | | | | | | | |
| 423701 | 2.1-2.7 | 8-26-76 | 227 | 88 | 14 | -- | 5 | -- |
| 423702 | | 12-15-76 | 61 | 83 | 0 | -- | 0 | -- |
| 423703 | | 3-08-77 | 76 | 44 | 0 | 0 | 0 | 0 |
| 423704 | | 6-01-77 | 114 | 44 | 0 | -- | 0 | -- |
| 423901 | 9.3-10.5 | 8-26-76 | 212 | 77 | 0 | -- | 0 | -- |
| 423902 | | 12-13-76 | 76 | 99 | 0 | -- | 0 | -- |
| 423903 | | 3-06077 | 170 | 94 | 0 | 0 | 0 | 0 |
| 423904 | | 6-01-77 | 132 | 55 | 0 | -- | 0 | -- |
| 424002 | 15.4-16.6 | 12-16-76 | 151 | 22 | 0 | -- | 0 | -- |
| 424004 | | 6-01-77 | 121 | 39 | 0 | -- | 0 | -- |

[a] Volume of concentrate includes 10% fetal calf serum.

[b] Buffalo Green Monkey

[c] Primary Baboon

(2 to 55 ft). In December, 1976, viruses were found in 7 of the 10 test wells beneath Basins I and II. However, in March, 1977, viruses were found in only 2 of the 10 wells and, in May, 1977, no viruses were detected in any of the 10 test wells (Figure 29).

Downgradient from the infiltration basins viruses occurred one time in shallow well 42370 which is 50 m (165 ft) from Basin II, and one time in the intermediate depth well 42390 which is 250 m (820 ft) from Basin II. However, no viruses were detected in deep well 42400 which is located next to well 42390.

It is significant that fecal coliforms occurred in well 43370 but were never found in wells 42390 or 42400. This and the supporting coliform data from Basins I and III reasonably define the limit of coliform movement in these sands. Considering viral particle size and electrical charge, it would be expected that viruses would travel further through permeable sands than coliforms.

Although the selected sampling wells did not fully define the extent of virus movement downgradient, the decreasing number in well 42390 and the negative results in well 42400 indicate that viruses probably do not move much further downgradient.

During round 2 (December, 1976), virus samples were also concentrated using the bentonite technique developed by the U.S. Army Bioengineering Research and Development Laboratory, Ft. Detrick, MD (Shaub, 1977). The results obtained by the Ft. Detrick Laboratory are shown in Table 22.

All samples from the control sites were negative for viruses. The treated effluent was positive for viruses on all four testing rounds. The test wells in Basin I and Basin II produced virus isolates in 18 out of 38 samples. However, only 2 of 10 samples from wells downgradient from Basin II showed positive for virus.

Selected positive virus samples were identified using neutralization tests. Of the 17 identifications, there were 5 polio viruses, 3 coxachie B4, and 9 echo viruses.

No attempts were made to differentiate the polio viruses into vaccine or wild strains. However, the National Center for Disease Control in Atlanta reported no cases of polio in the state of New Jersey for the study period. It is extremely difficult to correlate the isolation of echo viruses and coxachie viruses in wastewater or in water wells adjacent to wastewater irrigation sites. It must be assumed that human cases existed in the population served by the treatment plants; however, contact with New Jersey State Health Department Epidemiology Section failed to uncover any reported outbreaks of aseptic meningitis or exanthens during the study period.

### Surface Water

Surface waters from the Maurice River and the Tarkiln and the Parvin Branch tributaries were sampled in August, 1976, and March, 1977, at locations indicated in Figure 6 (page 22). Analyses of the surface water

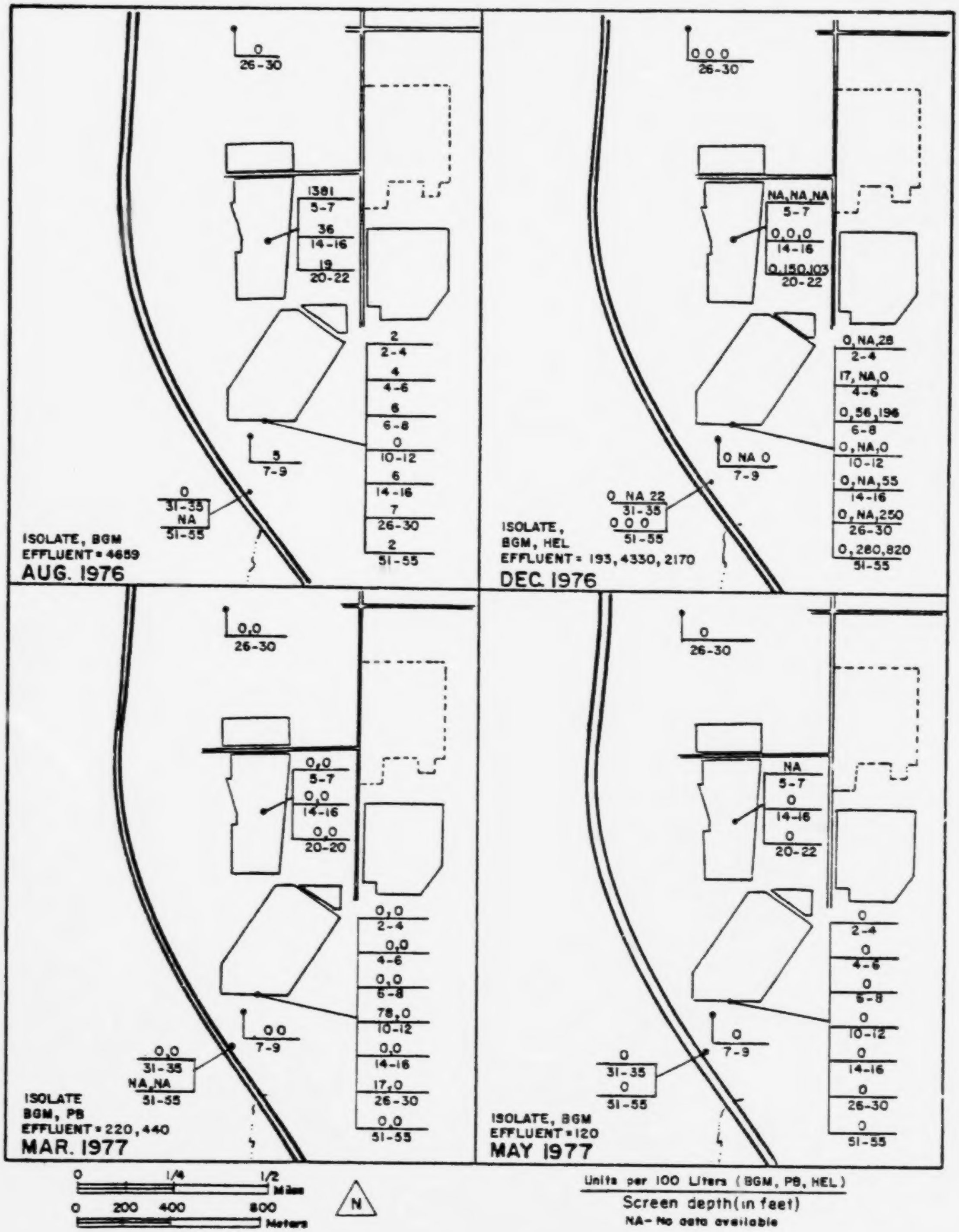

0
26-30
1381
5-7
36
14-16
19
20-22
2
2-4
4
4-6
6
6-8
0
10-12
6
14-16
7
26-30
2
51-55
5
7-9
0
31-35
NA
51-55
ISOLATE, BGM
EFFLUENT = 4659
AUG. 1976
0 0 0
26-30
NA,NA,NA
5-7
0,0,0
14-16
0,150,103
20-22
0,NA,28
2-4
17, NA,0
4-6
0,56,196
6-8
0,NA,0
10-12
0,NA,55
14-16
0,NA,250
26-30
0,280,820
51-55
0 NA 0
7-9
0 NA 22
31-35
0 0 0
51-55
ISOLATE,
BGM, HEL
EFFLUENT = 193, 4330, 2170
DEC. 1976
0,0
26-30
0,0
5-7
0,0
14-16
0,0
20-20
0,0
2-4
0,0
4-6
0,0
6-8
78,0
10-12
0,0
14-16
17,0
26-30
0,0
51-55
0 0
7-9
0,0
31-35
NA,NA
51-55
ISOLATE
BGM, PB
EFFLUENT = 220, 440
MAR. 1977
0
26-30
NA
5-7
0
14-16
0
20-22
0
2-4
0
4-6
0
6-8
0
10-12
0
14-16
0
26-30
0
51-55
0
7-9
0
31-35
0
51-55
ISOLATE, BGM
EFFLUENT = 120
MAY 1977
0 1/4 1/2
Miles
0 200 400 800
Meters
N
Units per 100 Liters (BGM, PB, HEL)
Screen depth (in feet)
NA - No data available

Figure 29. Groundwater constituents.- Infectious virus units.

TABLE 22. VIRUS ISOLATION BY THE BENTONITE METHOD

| Source Sample No. | Depth Screened (m) | Date Sampled | Original Volume of Sample (L) | Volume of Concentrate (mL) | Infectious Virus Units | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | per 100 mL of Concentrate | | per 100 L of Sample | |
| | | | | | BGM[a] | HEL[b] | BGM | HEL |
| Control Site Well | | | | | | | | |
| 410302 | 7.9-9.1 | 12-13-76 | 60 | 76 | 0 | 0 | 0 | 0 |
| PTP Effluent | | | | | | | | |
| 425502 | NA | 12-16-76 | 10 | 91 | 476 | 238 | 4330 | 2170 |
| Test Site Wells | | | | | | | | |
| Area I | | | | | | | | |
| 420902 | 4.3-4.9 | 12-14-76 | 40 | 100 | 0 | 0 | 0 | 0 |
| 421002 | 6.1-6.7 | 12-14-76 | 40 | 101 | 59 | 41 | 150 | 103 |
| Area II | | | | | | | | |
| 421702 | 0.6-1.2 | 12-16-76 | 40 | 111 | -- | 10 | -- | 28 |
| 421802 | 1.2-1.8 | 12-15-76 | 40 | 107 | -- | 0 | -- | 0 |
| 420402 | 1.8-2.4 | 12-15-76 | 40 | 110 | 20 | 71 | 56 | 196 |
| 421902 | 2.9-3.5 | 12-15-76 | 40 | 108 | -- | 0 | -- | 0 |
| 422002 | 4.3-4.9 | 12-14-76 | 40 | 109 | -- | 20 | -- | 55 |
| 420302 | 7.9-9.1 | 12-12-76 | 37 | 91 | -- | 102 | -- | 250 |
| 422102 | 15.5-16.8 | 12-11-76 | 30 | 150 | 56 | 164 | 280 | 820 |
| Downgradient from Area II | | | | | | | | |
| 423702 | 2.1-2.7 | 12-15-76 | 40 | 109 | -- | 0 | -- | 0 |
| 423902 | 9.3-10.5 | 12-13-76 | 42 | 91 | -- | 10 | -- | 22 |
| 424002 | 15.4-16.6 | 12-16-76 | 40 | 126 | 0 | 0 | 0 | 0 |

[a] Buffalo Green Monkey

[b] Human Embryo Lung

samples were compared to determine if there was evidence that the treatment or landfill sites affected groundwater discharges to the streams.

Statistical comparisons were made of the surface water for both the Maurice River and Parvin Branch using the same methods as in the groundwater analysis. The first analysis compares control surface water upstream of the treatment plant on the Maurice River with test surface water on the Maurice River downgradient from the treatment plant in the direction of groundwater flow. The control surface water is identified by stations 42500 and 42540. The test surface water is identified by stations 42510 and 42530. The results of the analysis in Table 23 show that no significant differences were identified for any of the parameters analyzed. The greater flow of the Maurice River has a significant effect on diluting the impact of infiltrating flow from the treatment plant.

The surface water for the Parvin Branch was analyzed in the same manner as the above analysis. The upstream control surface water for the Parvin Branch is identified as stations 42440, 42450, and 42480. The test surface water for the Parvin Branch located downgradient from the treatment plant in the direction of groundwater flow is identified as stations 42460, 42470, 42490, and 42520. The results of the analysis in Table 24 indicate mean concentrations for conductivity, total alkalinity, dissolved solids, chloride, dissolved organic carbon, boron, iron and sodium were significantly greater at the 0.05 level in the test surface water than in the control surface water. Except for iron, the same parameters occur in the Landis effluent in significantly greater concentrations than in the control groundwater. These results show the influence of the treatment system on the water quality in the Parvin Branch. Dissolved oxygen, calcium, and magnesium were found to have mean concentrations greater in the control surface water.

These concentrations indicate that approximately 75 percent of the 1.8 Mgal/d increase in stream flow below Basins II and III is infiltrated wastewater moving into the stream. Apparently 34 percent of the average daily infiltrated wastewater in Basins II and III had reached Parvin Branch above Station 42520. The groundwater contours (Figure 4, page 18) show that most of the remaining loading on Basins II and III will reach Parvin Branch prior to its confluence with the Maurice River.

Ammonium nitrogen did not show as significantly different at the 0.05 level; however, the total nitrogen when evaluated in terms of the stream flows did increase substantially. The control stream water with a flow of 1.15 Mgal/d had a total nitrogen concentration of 8.3 mg/L (0.6 total organic-N + 1.5 ammonia-N + 6.2 nitrate-N) as compared to the test stream water with a flow of 2.95 Mgal/d and a total nitrogen concentration of 12.0 mg/L (5.5 total organic-N + 3.8 ammonia-N + 2.7 nitrate-N) (Table 24).

Using the material balance equations shown in Table 25, the calculated concentration of the increased flow of 1.80 Mgal/d is 14.4 mg/L. A second material balance calculation utilizing the control groundwater concentration is necessary if it is accepted that 75 percent of this additonal flow is infiltrated wastewater. This gives a flow of 1.35 Mgal/d at a concentration of 17.9 mg/L, which compares to an average total nitrogen concentration in

TABLE 23. MEAN CONCENTRATIONS OF PARAMETERS IN MAURICE RIVER WATER UPSTREAM (CONTROL) AND DOWNSTREAM (TEST) OF THE TREATMENT PLANT

| Parameter | Means (mg/L unless noted) | |
|---|---|---|
| | Control | Test |
| Dissolved Oxygen | 9.6 | 9.1 |
| pH (units) | 6.4 | 6.5 |
| Conductivity (μmhos/cm) | 99 | 96 |
| Total Alkalinity | 10 | 8 |
| Dissolved Solids | 71 | 73 |
| Biochemical Oxygen Demand | 1.0[b] | 1.0[b] |
| Chemical Oxygen Demand | 22.3 | 20.3 |
| Chloride | 7 | 12 |
| Sulfide-S | 0.1[b] | 0.1[b] |
| Total Coliform (#/100 mL) | TNTC[c] | TNTC |
| Fecal Coliform (#/100 mL) | 1 | 9 |
| Dissolved Organic C | 5.7 | 5.2 |
| Soluble Organic N | 0.5 | 0.1 |
| Ammonium-N | 1.0 | 0.7 |
| Nitrate-N | 1.7 | 1.7 |
| Soluble Phosphorus | 0.08 | 0.07 |
| Soluble Orthophosphate | 0.04 | 0.03 |
| Sulfate | 16 | 16 |
| Aluminum | 0.5[b] | 0.5[b] |
| Arsenic (μg/L) | 193 | 202 |
| Boron (μg/L) | 199 | 149 |
| Cadmium (μg/L) | 20[b] | 20[b] |
| Calcium | 3 | 3 |
| Cobalt (μg/L) | 50[b] | 50[b] |
| Chromium (μg/L) | 22 | 20[b] |
| Copper (μg/L) | 20[b] | 20[b] |
| Iron | 0.6 | 1.0 |
| Lead (μg/L) | 100[b] | 100[b] |
| Magnesium | 3 | 3 |
| Manganese | 0.05[b] | 0.05[b] |
| Mercury (μg/L) | 1.0[b] | 1.0[b] |
| Nickel (μg/L) | 100[b] | 100[b] |
| Potassium | 1.8 | 2.1 |
| Sodium | 4 | 5 |
| Zinc (μg/L) | 20[b] | 20[b] |
| Selenium (μg/L) | 10[b] | 10[b] |
| Endrin (ng/L) | 0.03[b] | 0.03[b] |
| Lindane (ng/L) | 17.8 | 48.6 |
| Methoxychlor (ng/L) | 0.01[b] | 0.01[b] |
| Toxaphene (ng/L) | 0.1[b] | 0.1[b] |
| 2,4-D (ng/L) | 13.6 | 14.1 |
| 2,4,5 TP Silvex (ng/L) | 66.5 | 65.3 |

[a] Test and control sites are significantly different at the 0.05 level.
[b] Average concentrations below detection limit indicated.
[c] TNTC - At least one sample too numerous to count.

## TABLE 24. MEAN CONCENTRATIONS OF PARAMETERS IN PARVIN BRANCH WATER UPSTREAM (CONTROL) AND DOWNSTREAM (TEST) OF THE TREATMENT PLANT

| Parameter | Means (mg/L unless noted) Control | Test |
|---|---|---|
| Dissolved Oxygen | 8.9 | 5.3[a] |
| pH (units) | 6.7 | 6.8 |
| Conductivity (μmhos/cm) | 136 | 381[a] |
| Total Alkalinity | 18 | 63[a] |
| Dissolved Solids | 106 | 197[a] |
| Biochemical Oxygen Demand | 1.6 | 2.6 |
| Chemical Oxygen Demand | 16.0 | 23.0 |
| Chloride | 11 | 40[a] |
| Sulfide-S | 0.1[b] | 0.1[b] |
| Total Coliform (#/100 mL) | TNTC[c] | TNTC |
| Fecal Coliform (#/100 mL) | 400 | 13 |
| Dissolved Organic C | 2.2 | 4.7[a] |
| Soluble Organic N | 0.1[b] | 0.1[b] |
| Ammonium-N | 1.5 | 3.8 |
| Nitrate-N | 6.2 | 2.7 |
| Soluble Phosphorus | 0.04 | 0.04 |
| Soluble Orthophosphate | 0.04 | 0.06 |
| Sulfate | 7 | 12 |
| Aluminum | 0.5[b] | 0.5[b] |
| Arsenic (μg/L) | 21 | 10 |
| Boron (μg/L) | 83 | 245[a] |
| Cadmium (μg/L) | 20[b] | 20[b] |
| Calcium | 9 | 4[a] |
| Cobalt (μg/L) | 50[b] | 50[b] |
| Chromium (μg/L) | 20[b] | 20[b] |
| Copper (μg/L) | 20[b] | 20[b] |
| Iron | 0.4 | 6.9[a] |
| Lead (μg/L) | 100[b] | 100[b] |
| Magnesium | 6 | 4[a] |
| Manganese | 0.07 | 0.12 |
| Mercury (μg/L) | 1.0[b] | 1.0[b] |
| Nickel (μg/L) | 100[b] | 100[b] |
| Potassium | 4.7 | 6.2 |
| Sodium | 4 | 47[a] |
| Zinc (μg/L) | 30 | 20[b] |
| Selenium (μg/L) | 10[b] | 10[b] |
| Endrin (ng/L) | 0.03[b] | 0.03[b] |
| Lindane (ng/L) | 66.6 | 48.4 |
| Methoxychlor (ng/L) | 0.01[b] | 0.01[b] |
| Toxaphene (ng/L) | 0.1[b] | 0.1[b] |
| 2,4-D (ng/L) | 16.3 | 15.2 |
| 2,4,5 TP Silvex (ng/L) | 72.3 | 44.4 |

[a] Test and control sites are significantly different at the 0.05 level.
[b] Average concentrations below detection limit indicated.
[c] TNTC - At least one sample too numerous to count.

TABLE 25. CALCULATION AND COMPARISON OF INCREMENTAL FLOW CONCENTRATIONS OF STATISTICALLY SIGNIFICANT PARAMETERS

| | Parameter Means (mg/L unless noted) | | | | |
|---|---|---|---|---|---|
| | A | B | D | | |
| Parameter[a] | Control Surface Water (Table 24) | Test Surface Water (Table 24) | Computed[b] Material Balance | Test Groundwater Beneath Basin III (Table 12) | Groundwater Downgradient From Basin II (Table 16) |
| Conductivity (μmhos/cm) | 136 | 381 | 538 | 653 | 729 |
| Total Alkalinity | 18 | 63 | 92 | 161 | 211 |
| Dissolved Solids | 106 | 197 | 255 | 326 | 345 |
| Total Solids[c] | 115 | 208 | 267 | --- | --- |
| Chloride | 11 | 40 | 59 | 70 | 78 |
| Total Organic Carbon[c] | 3.0 | 7.5 | 10.4 | 33.6 | 9.0 |
| Dissolved Organic Carbon | 2.2 | 4.7 | 6.3 | 21.7 | 13.9 |
| Boron (μg/L) | 83 | 245 | 348 | 609 | 486 |
| Iron | 0.4 | 6.9 | 11.1 | 29.3 | 33.6 |
| Sodium | 4 | 47 | 74 | 86 | 100 |

[a] Parameters with mean concentrations significantly greater for the test surface water than control surface water (Table 24).

[b] Computed concentrations of constituents in groundwater as it enters Parvin Branch using the following material balance: $C_AQ_A + C_DQ_D = C_BQ_B$

$C_A$ = conc. in column A

$Q_A$ = Total flow in Parvin & Tarkiln Branches above basins = 1.51 + 0.27 = 1.78 cfs (Table 2)

$C_B$ = conc. in column B

$Q_B$ = Total flow in Parvin Branch below basins = 4.56 cfs (Table 2)

$C_D$ = conc. computed for column D

$Q_D = Q_B - Q_A$ (apparent contribution from groundwater) = 2.78 cfs

[c] Data from Appendix B, Table B-1.

the Landis effluent of 47.7 mg/L and in the groundwater beneath and downgradient from the basins of 21.2 mg/L.

All the salient parameters increase markedly as the Tarkiln Branch flows from station 42440 to station 42490 and at downstream stations 42470 and 42520 on the Parvin Branch. These increases are more obvious if the concentrations of incremental flow attributed to groundwater inflow below the basins is calculated as shown in Table 25.

The groundwater contribution is shown as 0.079 $m^3$/sec (2.78 cfs) or 1.8 Mgal/d and differs from the 1.92 Mgal/d increase in flows discussed under surface water because of the loss between stations 42450 and 42480. The high groundwater contribution along this reach of the stream is a result of some natural groundwater inflow of very low parameter concentrations plus the infiltrated effluent of high concentration.

The average concentration of the groundwater or infiltrated effluent before it enters the stream is determined from the average concentration of wells beneath Basin III and downgradient from Basin II. Those parameters which move through the soils relatively unchanged include conductivity, dissolved solids, chloride, boron, and sodium and the respective percentages of those parameter concentrations occurring in the increased stream flow as compared to the test groundwater are 78, 76, 79, 64, and 80.

## SOILS

Soil samples from the bottom of infiltration Basins I, II and III were taken at depths of 0 to 31, 95 to 105, and 295 to 305 cm in August, 1976, and March, 1977. Control samples were collected near each basin in areas unaffected by wastewater infiltration.

### Statistical Comparisons of the Soils

Statistical comparisons of the mean parameter concentrations for the soils of the test and control sites were performed using the method of pooled variances at the 0.05 level of significance. The analyses consist of three comparisons for the three depths sampled between the test and control sites. The results in Table 26 show significantly greater differences at the 0 to 31 cm depth to exist for pH, total organic nitrogen, total phosphorus, total sulfur, exchangeable calcium, extractable copper, lindane, 2,4,5 TP silvex, total aluminum, total calcium, total sodium, and total zinc for the test site soils than for the control site soils. For many of the metals, average concentrations were below the detection limit for both the test and control sites. Further, it is noted from Table 26 that, although a statistical comparison is not possible for extractable zinc and total copper because the average concentrations are below the detection limits for the control site, it does appear that the means for these two parameters are somewhat greater in the test site soils. For the remaining parameters at the 0-31 cm depth, no significant differences were found.

For the 95 to 105 cm depth, significantly greater mean concentrations were found for pH, total organic nitrogen, total phosphorus, available phosphorus, and total calcium in the test site soil than in the control site

TABLE 26. MEAN CONCENTRATIONS OF PARAMETERS IN CONTROL AND TEST SITE SOILS

| | Means (µg/L unless noted) | | | | | |
|---|---|---|---|---|---|---|
| Depth | 0-31 cm | | 95-105 cm | | 295-305 cm | |
| Parameter | Control | Test | Control | Test | Control | Test |
| pH (units) | 4.0 | 5.2[a] | 4.4 | 5.3[a] | 5.2 | 5.6 |
| Inorganic Nitrogen | 19.4 | 22.8 | 22.9 | 23.7 | 8.8 | 12.4 |
| Total Organic Nitrogen | 158 | 499[a] | 17 | 43[a] | 2 | 26[a] |
| Total Phosphorus | 25 | 240[a] | 31 | 126[a] | 17 | 99[a] |
| Available Phosphorus | 2 | 86 | 3 | 67[a] | 5 | 43[a] |
| Total Sulfur | 116 | 253[a] | 91 | 67 | 103 | 64 |
| Cation Exchange Capacity (meq/100g) | 0.9 | 0.8 | 0.5 | 0.3 | 0.4 | 0.4 |
| Extractable Aluminum | 45.7 | 41.8 | 61.3 | 86.5 | 44.3 | 38.7 |
| Extractable Boron | 0.51 | 0.27 | 0.07 | 0.19 | 0.18 | 0.31 |
| Extractable Cadmium | 0.05[b] | 0.05[b] | 0.05[b] | 0.05[b] | 0.05[b] | 0.05[b] |
| Exchangeable Calcium | 0.01 | 0.08[a] | 0.02 | 0.03 | 0.02 | 0.03 |
| Extractable Cobalt | 0.12[b] | 0.12[b] | 0.12[b] | 0.12[b] | 0.12[b] | 0.12[b] |
| Extractable Chromium | 0.05[b] | 0.05[b] | 0.05[b] | 0.05[b] | 0.05[b] | 0.05[b] |
| Extractable Copper | 0.2 | 9.9[a] | 0.3 | 5.8 | 0.3 | 5.0 |
| Extractable Iron | 52 | 36 | 33 | 24 | 29 | 39 |
| Extractable Lead | 0.8 | 5.1 | 0.5[b] | 0.5[b] | 0.5[b] | 0.5[b] |
| Exchangeable Magnesium (mg/g) | 0.01[b] | 0.01[b] | 0.01[b] | 0.01[b] | 0.01[b] | - |
| Extractable Maganese | 1.8 | 0.6 | 3.2 | 0.3 | 1.1 | 0.5 |
| Extractable Nickel | 0.1[b] | 0.1[b] | 0.1[b] | 0.1[b] | 0.1[b] | 0.1[b] |
| Exchangeable Potassium (mg/g) | 0.01[b] | 0.01[b] | 0.01[b] | 0.01[b] | 0.01[b] | 0.01[b] |
| Exchangeable Sodium (mg/g) | 0.01[b] | 0.01[b] | 0.01[b] | 0.01[b] | 0.01[b] | 0.01[b] |
| Extractable Zinc | 2.5[b] | 8.3[a] | 2.5[b] | 3.7 | 2.5[b] | 4.3 |
| Endrin (ng/g) | 0.6[b] | 0.6[b] | | | | |
| Lindane (ng/g) | 1.0 | 33.9[a] | | | | |
| Methoxychlor (ng/g) | 0.01[b] | 0.01[b] | | | | |
| Toxaphene (ng/g) | 0.6[b] | 0.6[b] | | | | |
| 2,4-D (ng/g) | 0.13[b] | 0.13[b] | | | | |
| 2,4,5 TP Silvex (ng/g) | 1.3 | 3.3[a] | | | | |
| Total Aluminum (mg/g) | 0.8 | 1.8[a] | 1.7 | 1.6 | 1.0 | 1.5 |
| Total Cadmium | 2[b] | 2[b] | 2[b] | 2[b] | 2[b] | 2[b] |
| Total Calcium (mg/g) | 0.05 | 0.15[a] | 0.04 | 0.07[a] | 0.08 | 0.07 |
| Total Cobalt | 2[b] | 2[b] | 2[b] | 2[b] | 2[b] | 2[b] |
| Total Chromium | 5[b] | 5[b] | 5[b] | 5[b] | 5[b] | 5[b] |
| Total Copper | 2[b] | 13[a] | 2[b] | 4 | 2[b] | 3 |
| Total Iron (mg/g) | 1.9 | 1.9 | 2.9 | 2.2 | 1.7 | 2.0 |
| Total Lead | 10[b] | 16 | 10[b] | 10[b] | 10[b] | 10[b] |
| Total Magnesium (mg/g) | 0.01[b] | 0.10 | 0.02 | 0.05 | 0.01[b] | 0.05 |
| Total Manganese | 43 | 39 | 57 | 51 | 41 | 36 |
| Total Mercury | 1.0[b] | 1.0[b] | 1.0[b] | 1.0[b] | 1.0[b] | 1.0[b] |
| Total Nickel | 20[b] | 20[b] | 20[b] | 20[b] | 20[b] | 20[b] |
| Total Potassium (mg/g) | 0.2[b] | 0.3 | 0.4 | 0.4 | 0.4 | 0.4 |
| Total Sodium (mg/g) | 0.06 | 0.16[a] | 0.10 | 0.15 | 0.13 | 0.19 |
| Total Zinc | 2 | 22[a] | 6 | 13 | 3 | 12[a] |
| Total Arsenic | 1.3 | 1.0 | 1.5 | 1.5 | 1.3 | 1.5 |
| Total Selenium | 0.6 | 0.8 | 0.5 | 0.6 | 0.5 | 0.6 |

[a] Test and control sites significantly different at the 0.05 level.
[b] Average concentration below detection limit indicated.

soil. Except for available phosphorus, these parameter means were also significantly greater at the 0 to 31 cm depth. The remaining eight parameters were not found to be significantly greater indicating retainage is occurring only at the shallower depths for these parameters. Finally, at the 295 to 305 cm depth, means for total organic nitrogen, total phosphorus, available phosphorus, and total zinc were significantly greater for the test site soils than the control site soils.

### Detailed Discussion

Selected parameters are plotted in Figures 30 through 34 as a function of depth below the basin surface and below the surface of the control soil area. For the test site parameters, concentrations generally decrease with depth below the basin surface. For the control site parameters, only organic nitrogen decreases regularly with depth. Total phosphorus and total zinc in the control site soils appear to be random with depth.

#### Nitrogen--

The total organic nitrogen concentrations (Figure 30) in the deeper test site soils tend to converge with the control site deep nitrogen concentrations. The differences between the organic nitrogen accumulated in Basin I soils and Basin III soils do not reflect the difference between 50 and 3 years of operation, respectively. But there is a stable level of organic nitrogen for a soil, which once reached, merely results in a higher annual liberation of ammonia. As already observed, the majority of the nitrogen is leaving the infiltration site via the groundwater.

#### Phosphorus--

While the total phosphorus concentrations of the deeper test site soils must converge with the respective concentrations in the deeper control site soils, Figure 31 indicated considerable accumulation throughout the depths sampled. The water quality data indicates that the phosphorus adsorption capacity of the soils immediately beneath Basins I and II has been severely reduced or exhausted, but that the soils beneath Basin III are apparently still active.

The average phosphorus concentration of the effluent is 9.0 mg/L and if a loading rate of 21.4 m (70 ft) for 3 years is assumed, then 5,740 kg/ha (5,114 lb/acre) has been applied to Basin III. Approximately 57 kg/ha (51 lb/acre) has percolated to the groundwater and 4,772 kg/ha (4,252 lb/acre) has accumulated in the first 300 cm (9.8 ft) of soil (Table 26). The excess phosphorus has likely accumulated below 300 cm (9.8 ft).

#### Copper and Zinc--

Similar balances were attemped for the three basins for copper and zinc. Loading rates for Basin I were assumed to average 11.3 m (37 ft) for 50 years. Loading rates for Basin II were assumed to average 21.4 m (70 ft) for a period of 29 years, but actual rates would have been less during the early years and greater prior to the completion of Basin III. An examination of Figure 32 shows that both parameters have accumulated in the soils and that the accumulation decreases with depth as would be expected. The water quality data indicates that both parameters are still being effectively removed from the wastewater.

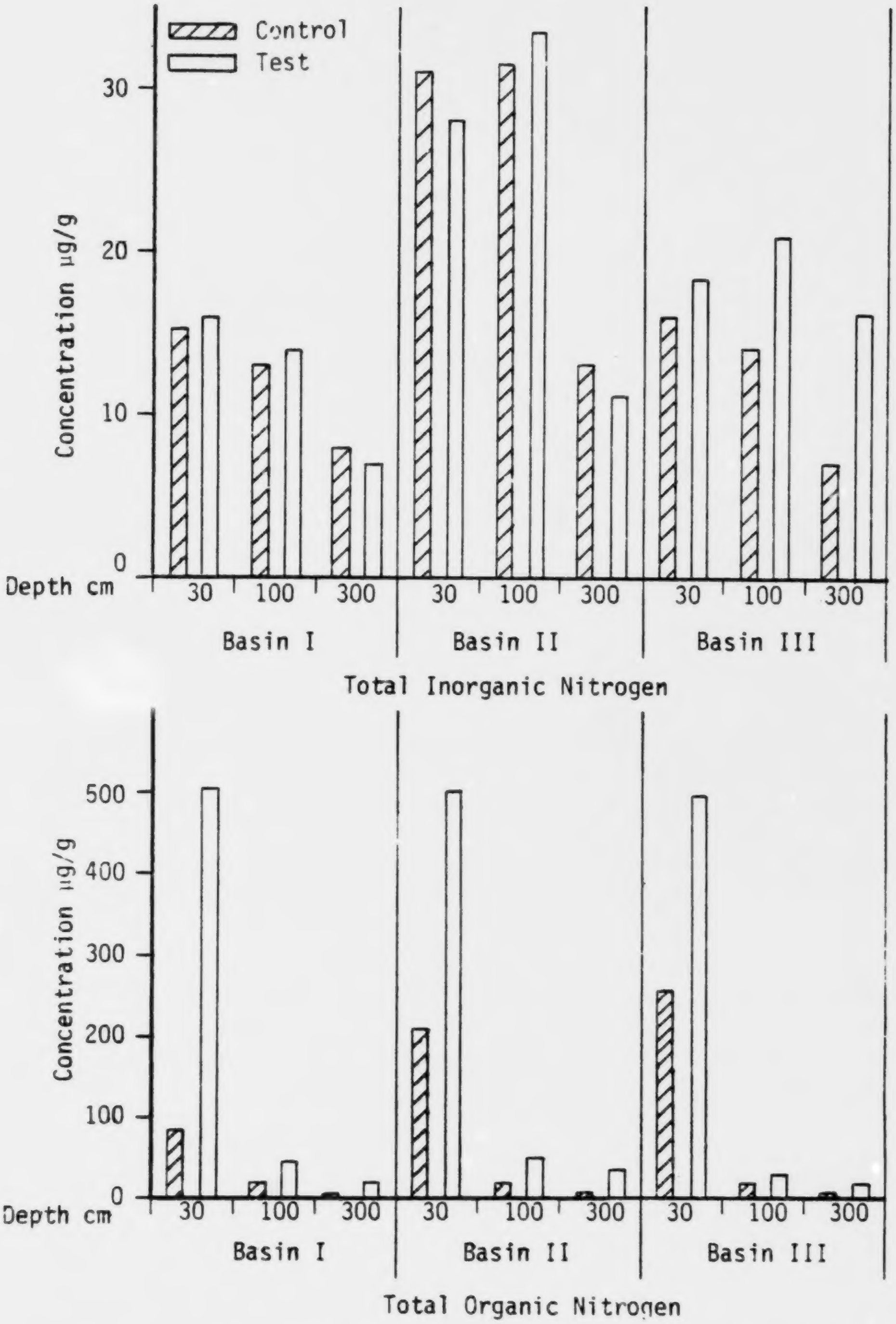
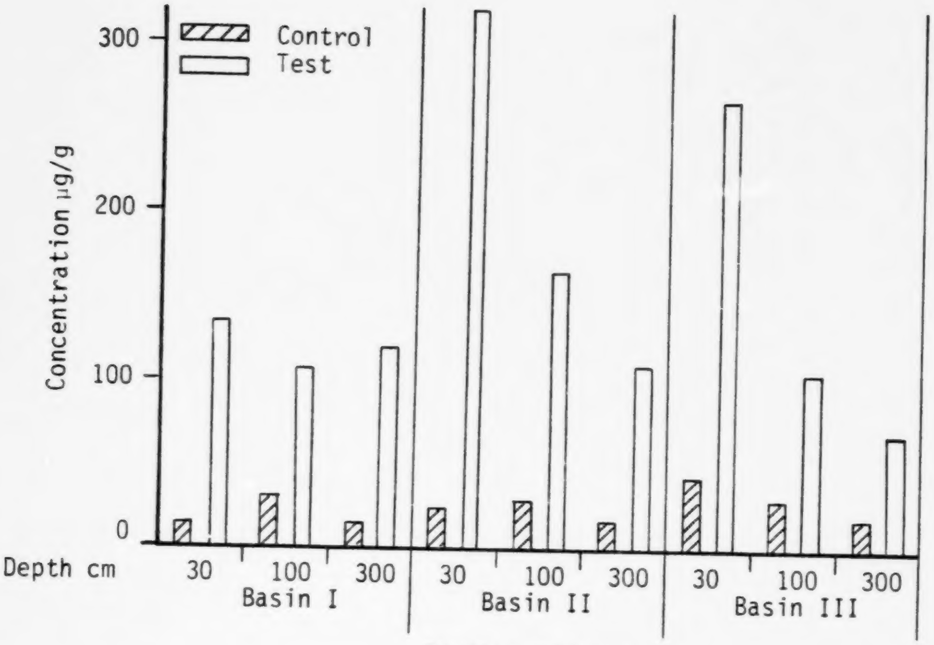
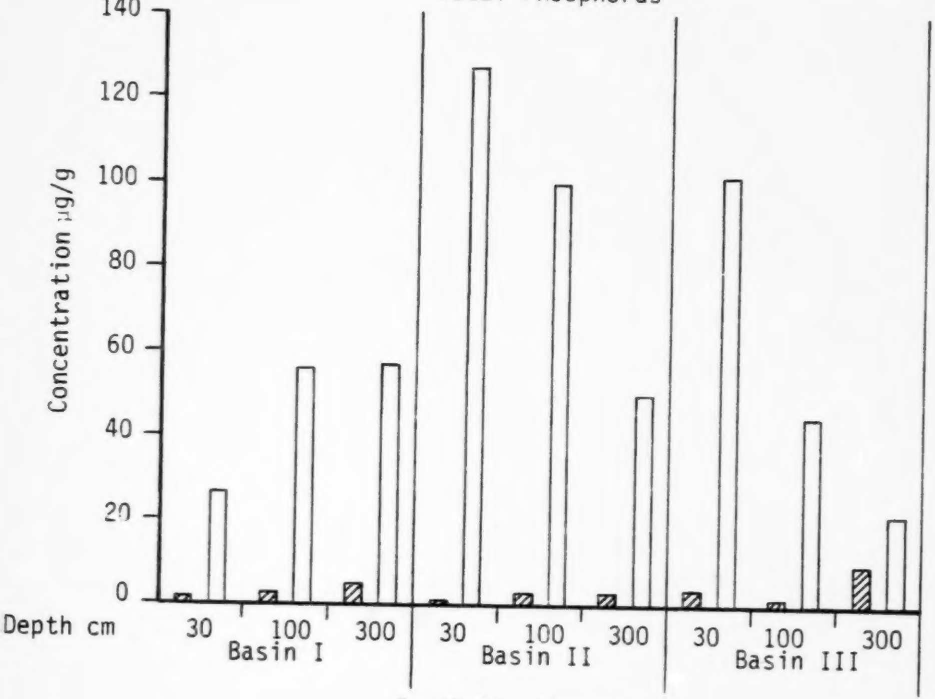


Figure 30. Total inorganic and organic nitrogen mean concentrations in control and test site soils.

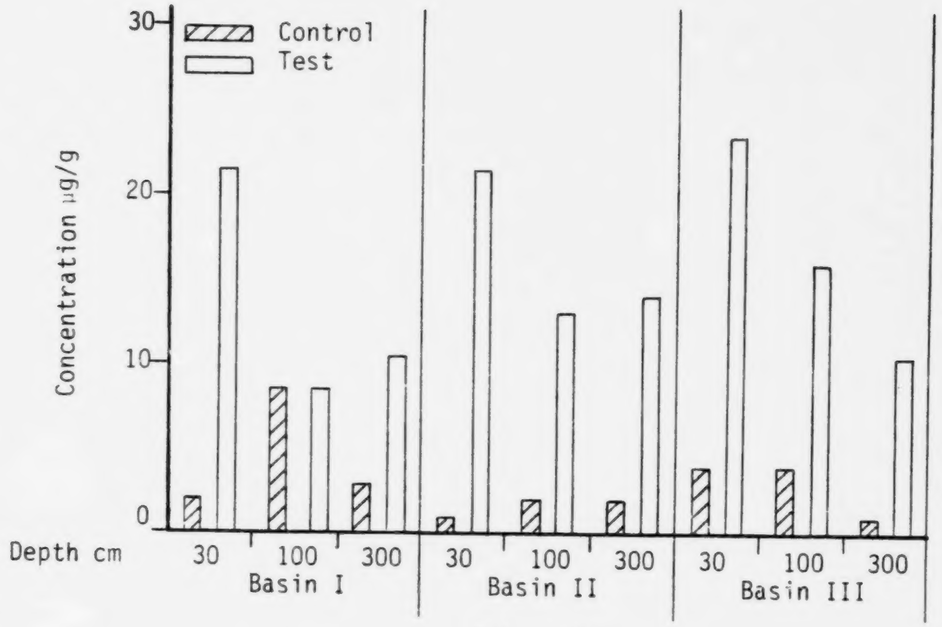


Total Phosphorus

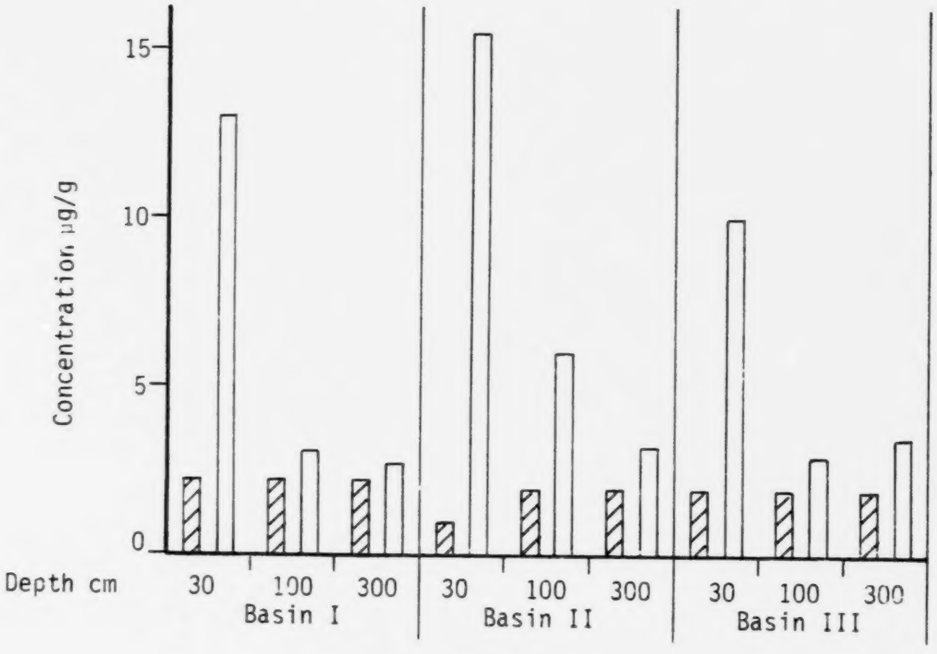


Available Phosphorus

Figure 31. Total and available phosphorus mean concentrations in control and test site soils

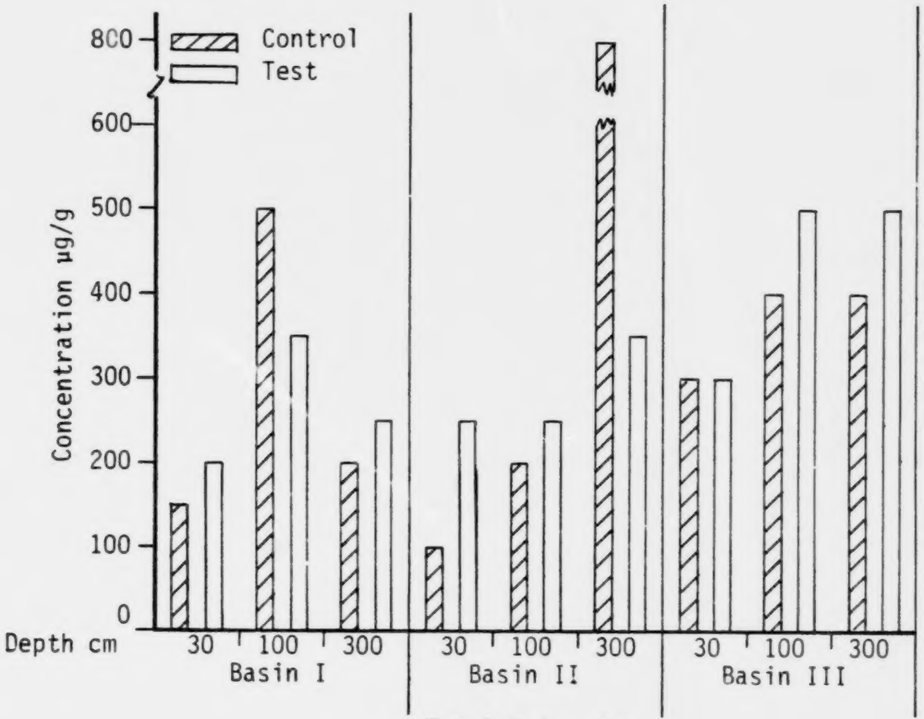


Total Zinc

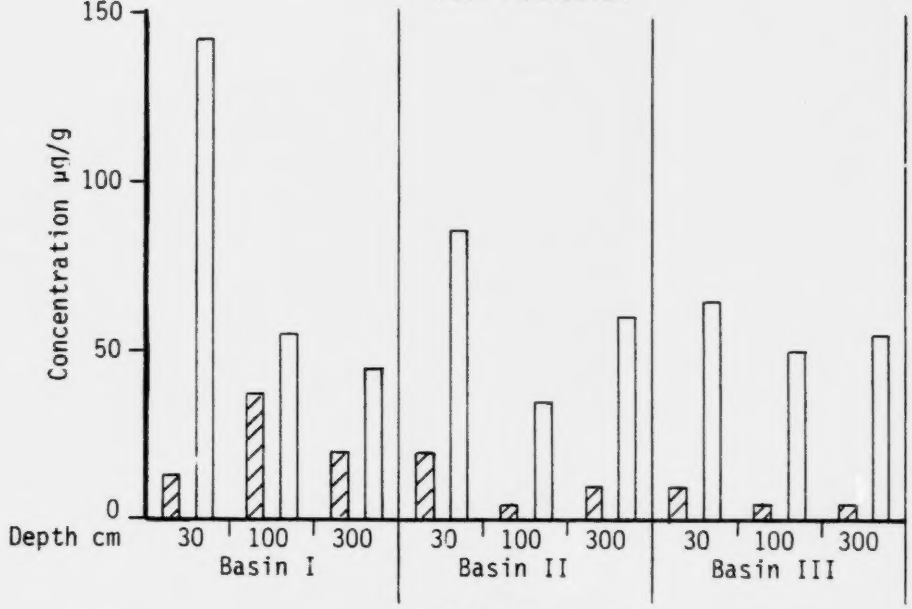


Total Copper

**Figure 32. Total zinc and copper mean concentrations in control and test site soils**

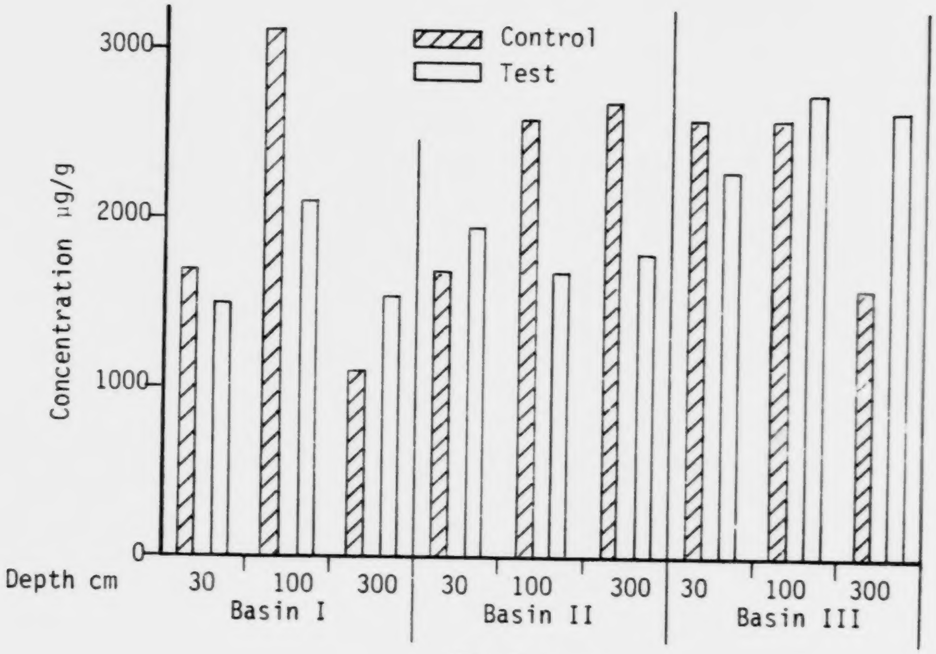


Total Potassium

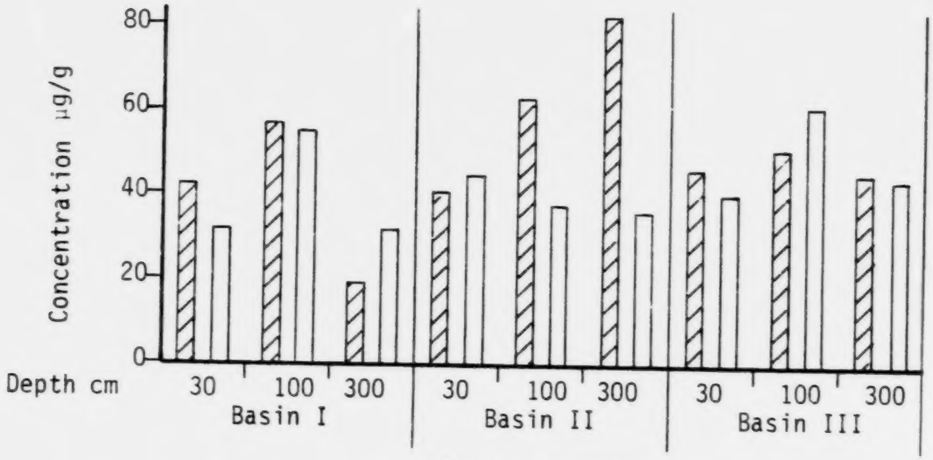


Total Magnesium

**Figure 33. Total potassium and magnesium mean concentrations in control and test site soils**



Total Iron



Total Manganese

**Figure 34.** Total iron and manganese mean concentrations in control and test site soils

Potassium, Calcium, Magnesium, and Sodium--

The water quality discussion of these parameters concluded that there was some uptake of calcium and magnesium by the soils while sodium and potassium were passing on through. However, in some cases, the water quality data appeared to conflict with these conclusions.

There was insufficient data to statistically compare the soils of the individual basins; however, the overall statistical comparison showed significantly more sodium and calcium at the 0 to 31 cm depth. At the 95-105 cm depth, only calcium was present in significantly greater amounts.

The graphical comparisons of the individual basins (Figure 33) show an apparent accumulation of magnesium but no apparent accumulation of potassium within the first 300 cm of the soils. Hence, the soils data generally substantiate the water quality conclusions regarding these parameters.

The parameter balances summarized in Table 27 are as variable as the data, but are still within the same range of magnitude and do show some relationship to loading rates and years of operation. An exception is noted for zinc accumulation in Basin III which is 8 times the amount applied.

Iron and Manganese--

The groundwater quality discussion concluded that iron and manganese were leaching from the soil. Figure 34 illustrates that leaching of iron has occurred beneath Basin I and that both iron and manganese have leached from the soil beneath Basin II.

An approximate materials balance indicates that 34,040 kg/ha (30,400 lb/acre) of iron has been leached from the first 300 cm of soil beneath Basin II. The average iron concentration in the groundwater beneath Basin II is 9 mg/L and the applied effluent averages 1.2 mg/L. The difference of 8 mg/L is equivalent to 668 kg (1,474 lb) per year and the first 300 cm of soil could have supplied this difference for 21 years. The iron concentration of the groundwater beneath Basin III is 29 mg/L which indicates that initially more than 7.8 mg/L would have been leached from Basin II and that much of the present concentration is coming from soil below 300 cm.

It is interesting to note that the average concentration of those wells beneath Basin II which are less than 100 cm deep is 5.3 mg/L, which reflects an increase in iron concentration of only 4.1 mg/L.

## PROJECTED USEFUL LIFE OF SITE FOR WASTEWATER INFILTRATION

The original intent of this study was to provide answers to a number of questions related to the long-term viability of land treatment systems. Two such questions discussed in the following paragraphs are:

1. For how long a period can a land treatment system be expected to provide satisfactory treatment for water?
2. What effect does continuing long-term application of organic, nitrogenous, and heavy metal constituents have on the soil system?

## TABLE 27. PHOSPHORUS, COPPER AND ZINC BALANCES

| Parameter | lb/acre Applied | Percolate to Groundwater | Accumulated in Soil | Not Accounted For |
|---|---|---|---|---|
| Phosphorus Basin III | 5114 | 51 | 4252 | 811 |
| Copper Basin I | 235 | 0 | 119 | 116 |
| Zinc Basin I | 634 | 0 | 297 | 337 |
| Copper Basin II | 421 | 0 | 231 | 190 |
| Zinc Basin II | 663 | 0 | 655 | 8 |
| Copper Basin III | 44 | 0 | 108 | -64 |
| Zinc Basin III | 69 | 0 | 551 | -482 |

The Vineland-Landis infiltration basin system has been discharging nitrogen constituents to the groundwater underlying the test site. While all three basins contribute to this discharge, Basin II contributes the largest concentrations, Basin I is next and Basin III was observed to contribute the least, but still sizeable, concentrations. Ammonium nitrogen is the form of nitrogen present in the highest concentration in all of the discharges.

Total nitrogen concentrations of the groundwater downgradient or beneath Basins I, II, and III varied with loading rates, unsaturated depth and service life and was 49, 58, and 43 percent, respectively, of the applied concentrations. The COD concentration downgradient from Basins I and II was 11 and 14 percent of the applied concentration. Immediately beneath Basins I and II the soluble phosphorus concentration was 30 and 76 percent of the applied concentration, respectively, but decreased to 3.2 and 4.3 percent downgradient. The concentration immediately beneath Basin III was only 1.4 percent of that applied.

Phosphorus is no longer accumulating in the soils immediately beneath infiltration Basins I and II. Phosphorus is still accumulating in the soils beneath Basin III which had only been in operation three years. Phosphorus is leaving the area monitored for this study at concentrations in the range of 0.1 mg/L which indicates that continuing phosphorus removal will depend upon downgradient soils that are not on the test site premises.

Metal constituents and particularly zinc, which have been observed to accumulate in the test soils, continue to be effectively removed to minimum detectable concentrations at monitoring wells immediately adjoining the infiltration basins. Based upon this performance after 50 and 29 year periods of operation, it is likely that the immediate test site can continue to provide another 50 years of satisfactory metals removal.

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# APPENDIX A

## WELL LOGS FOR CONTROL AND TEST SITES
## VINELAND, NEW JERSEY

### Drill Hole Logs

### Control Site

#### Hole 41010

Date: 8-21-76 Type Rig: Hollow-Stem Auger
Casing: 2-in. plastic to 45.5 ft.
Screen: 2-in. slotted (0.020 in.) plastic 45.5 to 49.5 ft.
Remarks: Casing and screen set through hollow-stem auger

| Log: | Depth in feet |
|---|---|
| 0-2 | Loam, sandy, organic, roots |
| 2-20 | Sand, fine to medium, brown |
| 20-30 | Sand, medium to coarse, with some gravel |
| 30-38 | Sand, fine to coarse |
| 38-45 | Gravel and sand |
| 45-48 | Sand, fine to medium |
| 48-50 | Clay |

#### Hole 41020

Date: 8-22-76 Type Rig: Hollow-Stem Auger
Casing: 2-in. plastic to 30 ft.
Screen: 2-in. slotted (0.020 in.) plastic 30 to 34 ft.
Remarks: Casing and screen set through hollow-stem auger

Log: Depth in feet

See Hole 41010

#### Hole 41030

Date: 8-22-76 Type Rig: Hollow-Stem Auger
Casing: 2-in. plastic to 26 ft.
Screen: 2-in. slotted (0.020 in.) plastic 26 to 30 ft.
Remarks: Casing and screen set through hollow-stem auger

Log: Depth in feet

See Hole 41010

### Hole 41040

Date: 8-22-76 Type Rig: Powered Hand Auger
Casing: 2-in. plastic to 19.5 ft.
Screen: 2-in. slotted (0.020 in.) plastic 19.5 to 21.5 ft.
Remarks: Hole augered to 25 ft., casing and screens jetted into place with city water.

Log: Depth in feet

| | |
|---|---|
| 0-1 | Soil, fine, sandy and silty |
| 1-25 | Sand, fine to coarse with scattered gravel, buff to brown |

### Hole 41050

Date: 3-5-77 Type Rig: Hollow-Stem Auger
Casing: 2-in. plastic to 56 ft.
Screen: 2-in. slotted (0.010 in.) plastic 56 to 60 ft.
Remarks: Casing and screens set through hollow-stem auger; split-spoon

Log: Depth in feet

| | |
|---|---|
| 0-17 | Sand, fine to medium, yellow |
| 17-50 | Sand, fine to medium, with fine gravel, yellow, sand coarser at base |
| 50-60 | Sand, fine to coarse, silty, trace of clay, fine gravel |

### Hole 41060

Date: 3-5-77 Type Rig: Hollow-Stem Auger
Casing: 2-in. plastic to 36 ft.
Screen: 2-in. slotted (0.010 in.) plastic 36 to 40 ft.
Remarks: Casing and screen pit through hollow-stem auger; aplit-spoon sample 38-38.5 ft.

Log: Depth in feet

| | |
|---|---|
| 0-0.7 | Soil, fine sandy, gray |
| .7-18 | Sand, fine to medium, brown to orange, some gravel |
| 18-35 | Sand, fine to coarse, orange to brown, with fine to coarse gravel |
| 35-40 | Sand, coarse, and gravel, medium |

(Continued)

## Study Site

### Hole T.H.-1

Date: 8-2-76 Type Rig: Hollow-Stem Auger
Casing: 2-in. plastic to 5.5 ft.
Screen: 2-in. slotted (.010 in.) plastic 5.5 to 9.5 ft.
Remarks: Split-spoon sample 5-7.5 ft.

Log: Depth in feet

| | |
|---|---|
| 0-2 | Sand, loose, damp, fine to medium, gray-brown, trace small gravel |
| 2-12.5 | Sand, moist, blue-brown, fine to medium, trace small gravel and silt. |
| 12.5-17.5 | Sand, dense, wet, fine to medium, brown, trace fine to coarse gravel |
| 17.5-25 | Sand, dense, fine to coarse, brown, some fine to coarse gravel |
| 25-30 | Sand, dense, wet, fine to coarse, brown, gravel, trace of silt |

### Hole T.H.-2

Date: 8-2-76 Type Rig: Hollow-Stem Auger
Casing: 2-in. plastic to 7 ft.
Screen: 2-in. slotted (.010 in.) plastic 7 to 11 ft.
Remarks: Split-spoon sample 7.5-10 ft.

Log: Depth in feet

| | |
|---|---|
| 0-5 | Sand, medium dense, damp, fine to medium, brown, trace fine to medium gravel |
| 5-7.5 | Sand, medium dense, fine to medium, yellow-brown, trace fine to medium gravel |
| 7.5-10 | Sand, medium dense, fine to medium, brown, trace fine to coarse gravel |
| 10-30 | Sand, very dense, fine to coarse, brown, trace fine to coarse gravel |

### Hole T.H.-3

Date: 8-13-76 Type Rig: Powered Hand Auger
Casing: 2-in. plastic to 23 ft.
Screen: 2-in. slotted (.030 in.) plastic 23 to 25 ft.
Remarks: Hole augered to 21 ft., and jetted with city water to 25 ft.

(Continued)

Log: Depth in feet

| | |
|---|---|
| 0-15 | Sand, fine to medium, moist, brown |
| 15-18 | Sand, fine to medium, brown, wood/fragments |
| 18-25 | Sand, fine to coarse, brown, gravel at 25 ft. |

### Hole T.H.-4

Date: 8-14-76 Type Rig: Powered Hand Auger
Casing: 2-in. plastic to 17 ft.
Screen: 2-in. slotted (.020 in.) plastic 17 to 19 ft.
Remarks: Hole augered to 15 ft., jetted with city water to 19 ft.

Log: Depth in feet

| | |
|---|---|
| 0-5 | Sand, fine to medium, gray |
| 5-19 | Sand, fine to medium, brown |

### Hole T.H.-5

Date: 8-14-76 Type Rig: Powered Hand Auger
Casing: 2-in. plastic to 11 ft.
Screen: 2-in. slotted (.020 in.) plastic 11 to 13 ft.

Remarks: Hole augered to 15 ft., caved back to 3 ft., jetted screen to 13 ft. with city water

Log: Depth in feet

| | |
|---|---|
| 0-0.5 | Soil, dark, organic |
| 0.5-15 | Sand, fine to medium, gray |

### Hole T.H.-7

Date: 8-14-76 Type Rig: Powered Hand Auger
Casing: 2-in. plastic to 12 ft.
Screen: 2-in. slotted (.020 in.) plastic 12 to 14 ft.
Remarks: Augered to 6 ft., jetted to 14 ft. with city water

Log: Depth in feet

| | |
|---|---|
| 0-14 | Sand, fine to medium gray-brown |

### Hole T.H.-8

Date: 8-14-76 Type Rig: Powered Hand Auger
Casing: 2-in. plastic to 9.5 ft.
Screen: 2-in. slotted (.020 in.) plastic 9.5 to 11.5

(Continued)

Remarks: Augered to 6 ft., jetted with city water to 11.5 ft.

Log: Depth in feet

| | |
|---|---|
| 0-8 | Sand, fine to medium, brown |
| 8-11.5 | Sand, fine to coarse, some small gravel and gravel at base |

### Hole 42020

Date: 8-22-76 Type Rig: Powered Hand Auger
Casing: 2-in. plastic to 7.5 ft.
Screen: 2-in. continuous slot (.020 in.) plastic 7.5 to 9.5 ft.
Remarks: Augered to 12 ft., split-spoon sample 10-12 ft.

Log: Depth in feet

| | |
|---|---|
| 0-1 | Sand, fine, gray-white |
| 1-3.5 | Sand, fine to medium, brown |
| 3.5-12 | Sand, medium to coarse, gray, organic odor |

### Hole 42030

Date: 8-20-76 Type Rig: Hollow-Stem Auger
Casing: 2-in. plastic to 26 ft.
Screen: 2-in. slotted (.020 in.) plastic 26 to 30 ft.
Remarks: Casing and screen set through hollow-stem auger

Log: Depth in feet

| | |
|---|---|
| 0-15 | Sand, fine to coarse, gray |
| 15-22 | Sand, medium-coarse, small gravel |
| 22-30 | Sand, coarse, gray |

### Hole 42040

Date: 8-18-76 Type Rig: Powered Hand Auger
Casing: 2-in. plastic to 6 ft.
Screen: 2-in. slotted (.020 in.) plastic 6 to 8 ft.
Remarks: Bottom of infiltration pit considered ground level

Log: Depth in feet

| | |
|---|---|
| 0-8 | Sand, fine to medium, dark gray |

### Hole 42050

Date: 8-20-76 Type Rig: Hollow-Stem Auger
Casing: 2-in. plastic to 25.5 ft.
Screen: 2-in. slotted (.020 in.) plastic 25.5 to 29.5 ft.
Remarks: Casing and screen set through hollow-stem auger

(Continued)

| Log: | Depth in feet |
|---|---|
| 0-6 | Fill for dike |
| 6-17 | Sand, fine to medium, gray to brown |
| 17-21 | Sand, medium to coarse, gray |
| 21-30 | Sand, coarse, gray, and small to medium gravel |

Hole 42060

Date: 8-21-76 Type Rig: Hollow-Stem Auger
Casing: 2-in. plastic to 58 ft.
Screen: 2-in. wire-wound, continuous slot (.020 in.) plastic 58 to 60 ft.
Remarks: Casing and screen set through hollow-stem auger

| Log: | Depth in feet |
|---|---|
| 0-44 | Sand, fine to medium, gray-brown |
| 44-59 | Clay, brownish-white |
| 59-51 | Sand, fine |
| 51-55 | Clay, with sand streaks |
| 55-60 | Sand, coarse, with gravel |

Hole 42070

Date: 8-15-76 Type Rig: Powered Hand Auger
Casing: 2-in. plastic to 2 ft.
Screen: 2-in slotted (.020 in.) plastic 2 to 4 ft.
Remarks: Augured to 4 ft., floor of infiltration pit considered ground level

| Log: | Depth in feet |
|---|---|
| 0-4 | Sand, fine to medium, gray |

Hole 42080

Date: 8-15-76 Type Rig: Water Jet
Casing: 2-in. plastic to 5 ft.
Screen: 2-in. slotted (.020 in.) plastic 5 to 7 ft.
Remarks: Floor of infiltration pit considered ground level, screen jetted into place with City water

| Log: | Depth in feet |
|---|---|
| 0-7 | Sand, fine to medium, gray |

(Continued)

### Hole 4209 0

Date: 8-15-76 Type Rig: Water Jet
Casing: 2-in. plastic to 14 ft.
Screen: 2-in. slotted (.020 in.) plastic 14 to 16 ft.
Remarks: Casing and screen jetted into place with city water, floor of infiltration pit considered ground level.

Log: Depth in feet

| | |
|---|---|
| 0-16 | Sand, fine to medium, gray |

### Hole 4210 0

Date: 8-15-76 Type Rig: Powered Hand Auger
Casing: 2-in. plastic to 20 ft.
Screen: 2-in. slotted (.020 in.) plastic 20-22 ft.
Remarks: Augured to 12 ft., jetted to 22 ft. with city water; floor of infiltration pit considered ground level

Log: Depth in feet

| | |
|---|---|
| 0-22 | Sand, fine to medium, gray |

### Hole 4211 0

Date: 8-20-76 Type Rig: Hollow-Stem Auger
Casing: 2-in. plastic to 41 ft.
Screen: 2-in. slotted (.020 in.) plastic 41 to 45 ft.
Remarks: Casing and screen set through hollow-stem auger

Log: Depth in feet

| | |
|---|---|
| 0-28 | Sand, fine to medium, gray |
| 28-38 | Sand, coarse, gray, small gravel |
| 38-43 | Sand, fine to medium |
| 43-44 | Sand, medium to coarse, with gravel |
| 44-45 | Clay, sandy, pinkish red |

### Hole 42120

Date: 8-15-76 Type Rig: Powered Hand Auger
Casing: 2-in. plastic to 2 ft.
Screen: 2-in. slotted (.020 in.) plastic 2 to 4 ft.
Remarks: Augered hole, floor of infiltration pit considered ground level

Log: Depth in feet

| | |
|---|---|
| 0-4 | Sand, fine to medium, gray |

(Continued)

### Hole 42130

Date: 8-15-76 Type Rig: Powered Hand Auger
Casing: 2-in. plastic to 5 ft.
Screen: 2-in. slotted (.020 in.) plastic 5 to 7 ft.
Remarks: Augered hole, floor of infiltration pit considered ground level

Log: Depth in feet

| | |
|---|---|
| 0-7 | Sand, fine to medium, gray |

### Hole 42140

Date: 8-15-76 Type Rig: Water Jet
Casing: 2-in. plastic to 9 ft.
Screen: 2-in. slotted (.020 in.) plastic 9 to 11 ft.
Remarks: Casing and screen jetted into position with city water, floor of infiltration pit considered ground level

Log: Depth in feet

| | |
|---|---|
| 0-11 | Sand, fine to medium, gray |

### Hole 42150

Date: 8-15-76 Type Rig: Water Jet
Casing: 2-in. plastic to 15 ft.
Screen: 2-in. slotted (.020 in.) plastic 15 to 17 ft.
Remarks: Casing and screen jetted into position, floor of infiltration pit considered ground level

Log: Depth in feet

| | |
|---|---|
| 0-17 | Sand, fine to medium, gray |

### Hole 42160

Date: 8-20-76 Type Rig: Hollow-Stem Auger
Casing: 2-in. plastic to 65 ft.
Screen: 2-in. slotted (.020 in.) plastic 65 to 70 ft.
Remarks: Casing and screen set through hollow-stem auger

Log: Depth in feet

| | |
|---|---|
| 0-6 | Fill, dike |
| 6-16 | Sand, fine to medium, gray |
| 16-41 | Sand, fine to coarse, gray, small to medium gravel |
| 41-45 | Sand, fine, silty, occasional gravel |
| 45-51 | Sand, fine to medium, brownish |
| 51-65 | Sand, very fine to fine, silty, clay streaks, brown |
| 65-70 | Sand, medium to coarse, small gravel |

(Continued)

### Hole 42170

Date: 8-18-76 Type Rig: Powered Hand Auger
Casing: 2-in. plastic to 2 ft.
Screen: 2-in. wire-wound continuous slot (.020 in.) plastic 2 to 4 ft.
Remarks: Augered hole, floor of infiltration pit considered ground level

| Log: | Depth in feet |
|---|---|
| 0-4 | Sand, fine to medium, gray |

### Hole 4218 0

Date: 8-18-76 Type Rig: Powered Hand Auger
Casing: 2-in. plastic to 4 ft.
Screen: 2-in. slotted (.020 in.) plastic 4 to 6 ft.
Remarks: Augered hole, floor of infiltration pit considered ground level

| Log: | Depth in feet |
|---|---|
| 0-6 | Sand, fine to medium, gray |

### Hole 4219 0

Date: 8-18-76 Type Rig: Water Jet
Casing: 2-in. plastic to 9.5 ft.
Screen: 2-in. slotted (.020 in.) plastic 9.6 to 11.6 ft.
Remarks: Jetted to 11.6 ft. with city water, floor of infiltration pit considered ground level

| Log: | Depth in feet |
|---|---|
| 0-11.6 | Sand, fine to medium, coarse sand or gravel at base |

### Hole 42200

Date: 8-18-76 Type Rig: Water Jet
Casing: 2-in. plastic to 14 ft.
Screen: 2-in. slotted (.020 in.) plastic 14 to 16 ft.
Remarks: Screen jetted into position with city water, floor of infiltration pit considered ground level

| Log: | Depth in feet |
|---|---|
| 0-14 | Sand, fine to medium, gray |
| 14-16 | Sand, coarse, gray, small gravel |

(Continued)

### Hole 42210

Date: 8-20-76 Type Rig: Hollow-Stem Auger
Casing: 2-in. plastic to 51 ft.
Screen: 2-in. slotted (.020 in.) plastic 51 to 55 ft.
Remarks: Casing and screen set through hollow-stem auger

| Log: | Depth in feet |
|---|---|
| 0-18 | Sand, fine to medium, gray |
| 18-20 | Sand, coarse, gravel |
| 20-32 | Sand, fine to medium |
| 32-34 | Sand, very coarse, gravel |
| 34-47 | Sand, fine to medium, brown |
| 47-55 | Sand, medium to coarse |

### Hole 42220

Date: 8-17-76 Type Rig: Water Jet
Casing: 2-in. plastic to 7 ft.
Screen: 2-in. slotted (0.020 in.) plastic 7 to 9 ft.
Remarks: Screen jetted into position with city water

| Log: | Depth in feet |
|---|---|
| 0-9 | Sand, fine to medium, gray |

### Hole 42230

Date: 8-16-76 Type Rig: Water Jet
Casing: 2-in. plastic to 26 ft.
Screen: 2-in. slotted (0.020 in.) plastic 26 to 28 ft.
Remarks: Screen jetted into position with city water

| Log: | Depth in feet |
|---|---|
| 0-28 | Sand, fine to medium, gray, with coarse sand and gravel at base |

### Hole 42240

Date: 8-17-76 Type Rig: Water Jet and Power Auger
Casing: 2-in. plastic to 13 ft.
Screen: 2-in. slotted (0.020 in.) plastic 13 to 15 ft.
Remarks: Hole augered and screens jetted into position with city water

| Log: | Depth in feet |
|---|---|
| 0-15 | Sand, fine to medium, gray, with coarse sand and gravel at base. |

(Continued)

### Hole 42250

Date: 8-17-76 Type Rig: Water jet and Power Auger
Casing: 2-in. plastic to 23 ft.
Screen: 2-in. slotted (0.020 in.) plastic 23 to 25 ft.
Remarks: Hole augered and screens jetted into position

| Log: | Depth in feet |
|---|---|
| 0-19 | Sand, fine to medium, gray |
| 19-21 | Gravel, coarse, sand, coarse |
| 21-25 | Sand, medium to coarse, gray |

### Hole 42260

Date: 8-20-76 Type Rig: Powered Hand Auger
Casing: 2-in. plastic to 6 ft.
Screen: 2-in. slotted (0.020 in.) plastic 6 to 8 ft.
Remarks: Hole augered to 12 ft.

| Log: | Depth in feet |
|---|---|
| 0-3 | Sand, fine to medium, gray |
| 3-6 | Sand, fine to medium, reddish |
| 6-12 | Sand, fine to medium, white |

### Hole 42270

Date: 8-20-76 Type Rig: Powered Hand Auger
Casing: 2-in. plastic to 6 ft.
Screen: 2-in. slotted (0.020 in.) plastic 6-8 ft.
Remarks: Hole augered to 9 ft.

| Log: | Depth in feet |
|---|---|
| 0-6 | Sand, fine to medium, reddish |
| 6-9 | Sand, fine to medium, white |

### Hole 42280

Date: 8-22-76 Type Rig: Hollow-Stem Auger
Casing: 2-in. plastic to 26.5 ft.
Screen: 2-in. slotted (0.020 in.) plastic 26.5 to 30 ft.
Remarks: Casing and screen set through hollow-stem auger; split spoon sample 10-12 ft.

| Log: | Depth in feet |
|---|---|
| 0-22 | Sand, fine to medium, gray |
| 22-30 | Sand, coarse, and scattered fine gravel |

(Continued)

### Hole 42290

Date: 8-22-76 Type Rig: Hollow-Stem Auger
Casing: 2-in. plastic to 46 ft.
Screen: 2-in. slotted (0.020 in.) plastic 46-50 ft.
Remarks: Casing and screen set through hollow-stem auger; split-spoon sample 25-27 ft.

Log: Depth in feet

| | |
|---|---|
| 0-3 | Sand, fine to medium organic |
| 3-18 | Sand, fine to medium, becoming coarser with depth, tan color |
| 18-23 | Sand, medium to coarse |
| 23-50 | Sand and gravel, with heavy gravel at 30 ft. |

### Hole 4230 0

Date: 8-21-76 Type Rig: Powered Hand Auger
Casing: 2-in. plastic to 3 ft.
Screen: 2-in. slotted (0.020 in.) plastic 3 to 5 ft.
Remarks: Augered to 6 ft. pushed screen and casing to 5 ft.

Log: Depth in feet

| | |
|---|---|
| 0-2.5 | Sand, medium to coarse, with coarse gravel, poorly salted, gray to white |
| 2.5-6 | Sand, medium, with gravel, brown, very organic odor |

### Hole 4231 0

Date: 8-21-76 Type Rig: Powered Hand Auger
Casing: 2-in. plastic to 10 ft.
Screen: 2-in. slotted (0.020 in.) plastic 10 to 12 ft.
Remarks: Augered to 15 ft., jetted screen into position with City water

Log: Depth in feet

| | |
|---|---|
| 0-2 | Sand, medium, poorly sorted, with gravel, gray to white |
| 2-6 | Sand, fine to medium, poorly sorted, with gravel, brown, organic odor |
| 6-10 | Sand, medium, with gravel, yellow-brown color |
| 10-11 | Sand, coarse, yellow with large gravel |
| 11-13 | Sand, medium, some gravel, yellow-brown |
| 13-15 | Gravel, with medium to coarse sand |

(Continued)

### Hole 4235 0

Date: 8-23-76 Type Rig: Hollow-Stem Auger
Casing: 2-in. plastic to 39.5 ft.
Screen: 2-in. continuous slot (0.020 in.) plastic 39.5 to 45 ft.
Remarks: Casing and screen set through hollow-stem auger

| Log: | Depth in feet |
|---|---|
| 0-45 | Sand and gravel with coarse sand and gravel between 25 and 30 ft. |

### Hole 42360

Date: 8-23-76 Type Rig: Hollow-Stem Auger
Casing: 2-in. plastic to 30.5 ft.
Screen: 2-in. slotted (0.02 in.) plastic 30.5 to 34.5 ft.
Remarks: Casing and screen set through hollow-stem auger

| Log: | Depth in feet |
|---|---|
| 0-5 | Sand, fine, gray |
| 5-20 | Sand, fine to medium, with granules |
| 20-25 | Sand, fine to medium, some gravel |
| 25-31 | Sand, medium to coarse, scattered gravel |
| 31-35 | Sand, coarse, gray, with gravel |

### Hole 4237 0

Date: 8-20-76 Type Rig: Powered Hand Auger
Casing: 2-in. plastic to 7 ft.
Screen: 2-in. slotted (0.020 in.) plastic 7 to 9 ft.
Remarks: Hole augered and screen pushed into position

| Log: | Depth in feet |
|---|---|
| 0-2 | Sand, medium, white |
| 2-7 | Sand, medium, red |
| 7-9 | Sand, medium, white |

### Hole 4238 0

Date: 8-14-76 Type Rig: Powered Hand Auger
Casing: 2-in. plastic to 14 ft.
Screen: 2-in. slotted (0.020 in.) plastic 14-16 ft.
Remarks: Hole augered to 6 ft., screen and casing jetted into position with City water

| Log: | Depth in feet |
|---|---|
| 0-12 | Sand, fine to medium, gray |
| 12-16 | Sand, coarse, and small gravel |

(Continued)

## Hole 42390

Date: 8-23-76 Type Rig: Hollow-Stem Auger
Casing: 2-in. plastic to 30.4 ft.
Screen: 2-in. slotted (0.020 in.) plastic 30.4 to 34.4 ft.
Remarks: Casing and screen set through hollow-stem auger

| Log: | Depth in feet |
|---|---|
| 0-35 | Sand, fine to coarse, with scattered gravel |

## Hole 42400

Date: 8-23-76 Type Rig: Hollow-Stem Auger
Casing: 2-in. plastic to 50.6 ft.
Screen: 2-in. slotted (0.020 in.) plastic 50.6 to 54.6 ft.
Remarks: Casing and screen set through hollow-stem auger

| Log: | Depth in feet |
|---|---|
| 0-5 | Sand, fine, white |
| 5-20 | Sand, fine to medium, white |
| 20-23 | Sand, coarse, with gravel |
| 23-31 | Sand, coarse |
| 31-39 | Sand, coarse, brown, heavy, with gravel |
| 39-45 | Sand, medium |
| 45-50 | Sand and clay interbedded |
| 50-65 | Sand, medium to coarse |
| 65-75 | Sand, with clay lenses |
| 75-80 | Sand, medium |

## Hole Pump-Test Well

Date: 3-5-77 Type Rig: Hollow-Stem Auger
Casing: 2-in. plastic to 30 ft.
Screen: 2-in. continuous slot (0.020 in.) plastic 20 to 32 ft; 34 to 36 ft.; and 38 to 40 ft.
Remarks: Casing and screens set through hollow-stem auger; hole is adjacent to 42280

| Log: | Depth in feet |
|---|---|
| 0-20 | Sand, fine to medium, gray |
| 20-40 | Sand, medium to coarse, with gravel, gray to brown |

## Hole Observation Well

Date: 3-5-77 Type Rig: Hollow-Stem Auger
Casing: 2-in. plastic to 11 ft.
Screen: 2-in. slotted (0.020 in.) plastic 11 to 15 ft.
Remarks: Casing and screen set through hollow-stem auger; hole is between pump test well and 42290

(Continued)

Log: Depth in feet

| | |
|---|---|
| 0-15 | Sand, fine to medium, becoming coarse at base, with fine to coarse gravel, brown to gray |

### Hole R-1

Date: 3-31-71
Casing: 6-in. plastic to 20 ft.
Screen: 6-in. plastic 20 to 25 ft.
Remarks: Landis Sewerage Authority water level recorder well

Log: Depth in feet

| | |
|---|---|
| 0-3.5 | Loam, sandy, fine, buff color |
| 3.5-12.5 | Sand, medium, red-buff color |
| 12.5-25 | Sand, medium to coarse, buff |

### Hole R-2

Date: 4-1-71
Casing: 6-in. plastic to 20 ft.
Screen: 6-in. plastic 20 to 25 ft.
Remarks: Landis Sewerage Authority water level recorder well

Log: Depth in feet

| | |
|---|---|
| 0-2 | Loam, sandy, gray to white |
| 2-11 | Sand, medium, gray to white |
| 11-25 | Sand, granules and pebbles, gray to white |

### Hole R-3

Date: 4-2-71
Casing: 6-in. plastic to 20 ft.
Screen: 6-in. plastic 20 to 25 ft.
Remarks: Landis Sewerage Authority water level recorder well

Log: Depth in feet

| | |
|---|---|
| 0-2 | Loam, sandy, gray |
| 2-7 | Sand, fine to medium, buff |
| 7-12 | Sand, medium, gray to white |
| 12-25 | Sand, granules, and pebbles, gray to white |

### Hole R-4

Date: 4-71
Screen: Stainless steel 0.008 in. slot 75 to 80 ft.
Remarks: Landis Sewerage Authority water level recorder well

(Continued)

| Log: | Depth in feet |
|---|---|
| 0-2 | Loam, sandy, gray to white |
| 2-7 | Sand, fine, buff |
| 7-13.5 | Sand, medium, gray to white |
| 13.5-27.5 | Granules, sandy, gray to white |
| 27.5-38 | Sand, gravel, with stones, white |
| 38-40.5 | Jersey stone (cemented conglomerate) |
| 40.5-45 | Clay, buff |
| 45-62 | Sand, buff |
| 62-68 | Jersey stone (cemented conglomerate) |
| 68-74 | Clay, gray, with streaks of gray sand |
| 74-80 | Sand, gray to buff |

# APPENDIX B

## DATA TABLES FOR ALL WATER AND SOIL SAMPLES

### LEGEND

Sample code numbers are explained in Section 7, "Results and Discussion."

99.9 means too numerous to count.

Negative sign (-) means less than.

Values in $\mu g/g \times 10^{-4}$ = percentage.

## TABLE B-1. WATER QUALITY DATA

| SAMPLE NUMBER | COLLECTION DATE | DEPTH M | TEMP DEG C | DISSOLVED OXYGEN MG/L | PH | CONDUC-TIVITY UMHOS/CM | TOTAL ALKALINITY MG/L CACO3 | DISSOLVED SOLIDS MG/L | SUSPENDED SOLIDS MG/L | TOTAL SOLIDS MG/L | VOLATILE SUSPENDED SOLIDS MG/L | BOD MG/L | COD MG/L | CL MG/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 416002 | 12/13/76 | | | 6.2 | 8.9 | 66. | 28. | 37 | | | | | | 4. |
| 416003 | 3/ 7/77 | | 1.6 | 7.5 | 7.3 | 66 | 24. | 63 | 3. | 66. | | 2. | 3. | 1. |
| 410301 | 8/24/76 | 7.9 | 1.5 | 9.4 | 4.4 | 49 | -2. | | | | | 2. | 4 | 1. |
| 410302 | 12/13/76 | 7.9 | | 8.8 | 4.5 | 52. | -2. | | | | | -1. | | 2. |
| 410303 | 3/ 3/77 | 7.9 | 1.2 | 8.6 | 4.5 | 79 | -2. | 23. | | | | 1. | 7. | 6. |
| 410304 | 5/26/77 | 7.7 | 1.3 | 9.0 | 4.7 | 45. | 4. | 23. | | | | -1. | 10. | 2. |
| 410201 | 8/24/76 | 9.1 | 1.3 | 8.8 | 5.4 | 64. | 8. | 37. | | | | 2. | | 2. |
| 410101 | 8/24/76 | 13.7 | 1.7 | 8.9 | 5.9 | 49. | 12. | | | | | 2. | | 1 |
| 410103 | 3/ 4/77 | 13.7 | 1.6 | 7.3 | 5.6 | 72. | 8. | | | | | -1. | 3. | 8. |
| 410104 | 5/26/77 | 13.7 | 2.0 | 9.2 | 6.6 | 103. | 24. | 76. | | | | -1. | 12. | 6. |
| 425601 | 8/26/76 | | | 0.9 | 5.6 | 848. | 116. | | | | | 143. | | 135. |
| 425602 | 12/13/76 | | | 2.6 | 6.9 | 433. | 136. | 163. | 19. | 182. | 9. | 90. | 237. | 31 |
| 425603 | 3/ 7/77 | | 0.8 | 2.1 | 7.0 | 477. | 116. | 268. | 54. | 326. | | 169. | 472. | 19. |
| 425604 | 5/27/77 | | | 0.4 | 6.3 | 432. | 92. | 211. | 56 | 267. | 45. | 215. | 408. | 42 |
| 422301 | 8/25/76 | 7.7 | 1.7 | -0.1 | 6.7 | 625. | 220. | | | | | 16. | 61. | 25. |
| 422303 | 3/ 3/77 | 7.9 | 1.7 | -0.1 | 6.9 | 472. | 180. | 203. | | | | 11. | 30. | 35 |
| 422304 | 5/31/77 | 7.9 | 0.8 | -0.1 | 6.8 | 601. | 231. | 259. | | | | 12. | 181. | 48. |
| 420801 | 8/24/76 | 1.5 | 2.6 | 0.3 | 6.7 | 415. | 84. | | | | | 14. | 235. | 20. |
| 420802 | 12/12/76 | 1.5 | | 1.2 | 6.4 | 828 | 68. | 369. | | | | 1. | 273. | 24. |
| 420803 | 3/ 3/77 | 1.5 | 1.3 | 1.3 | 6.3 | 774. | 60. | 472. | | | | 4. | 15 | 22 |
| 420804 | 5/31/77 | 1.5 | | 1.3 | 6.2 | 278. | 79. | 208. | | | | 14. | 215 | 35. |
| 420901 | 8/24/76 | 4.3 | 2.1 | -0.1 | 6.8 | 849 | 142. | | | | | 10. | | 23. |
| 420902 | 12/12/76 | 4.3 | | -0.1 | 6.4 | 472. | 168. | 202. | | | | 3 | 66. | 34. |
| 420903 | 3/ 5/77 | 4.3 | 77.7 | -0.1 | 7.1 | | 168. | 219. | | | | 7. | 35. | 41. |
| 420904 | 5/31/77 | 4.3 | 1.6 | -0.1 | 6.4 | 330. | 100. | 195 | | | | 14. | 96 | 37. |

(Continued)

TABLE B-1. Continued

| SAMPLE NUMBER | SULFIDE-SULFUR MG/L-S | TOTAL COLIFORM #/100ML | FECAL COLIFORM #/100ML | TOTAL ORGANIC CARBON MG/L-C | DISSOLVED ORGANIC CARBON MG/L-C | TOTAL ORGANIC NITROGEN MG/L-N | SOLUBLE ORGANIC NITROGEN MG/L-N | NH4 MG/L-N | NO3 MG/L-N | TOTAL PHOSPHORUS MG/L-P | SOLUBLE PHOSPHORUS MG/L-P | SOLUBLE ORTHO-PHOSPHATE MG/L-P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 416002 |  | 0. | 0 | -1.0 |  | 0.9 | 0.4 | 0.3 | 1.1 |  | 0.39 | 0.07 |
| 416003 | 0.1 | 0 | 0 |  | -0.5 |  | -0.1 | 0.3 | 2.5 |  | 0.20 | 0.04 |
| 410301 |  | 0. | 0. |  | -1.0 |  | 0.2 | -0.1 |  |  | 0.07 | 0.02 |
| 410302 |  | 400. | 0. | 2.0 |  |  |  | 0.4 | -0.1 |  | 0.02 | -0.01 |
| 410303 | -0.1 | 0. | 0. |  | -0.5 |  | 9.5 | 0.2 | -0.1 |  | 0.08 | 0.04 |
| 410304 | -0.1 | 0 | 0. |  | -0.5 |  | 0.5 | -0.1 | -0.1 |  | 0.02 | 0.02 |
| 410201 |  | 0 | 0. |  | -1.0 |  | 0.3 | -0.1 |  |  | -0.01 | -0.01 |
| 410101 |  | 0. | 0. |  | -1.0 |  | 0.8 | -0.1 |  |  | 0.41 | 0.15 |
| 410103 | -0.1 | 9. | 0. |  | -0.5 |  | 0.3 | -0.1 | 2.6 |  | 0.04 | -0.01 |
| 410104 | -0.1 | 0. | 0. |  | 3.0 |  | 1.0 | -0.1 | 2.1 |  | 0.02 | 0.02 |
| 425601 |  | 99.9 | 99.9 | 56.3 | 57.1 |  | 3.0 | 5.0 |  | 15.5 | 6.20 | 6.20 |
| 425602 |  | 400. | 0. | 89.4 | 60.6 | 29.2 | 19.8 | 22.8 | 0.1 | 6.00 | 4.50 | 4.00 |
| 425603 |  | 99.9 | 0. | 31.6 | 24.0 | 4.2 |  | 16.0 | 0.2 | 9.80 | 6.90 | 5.20 |
| 425604 | -0.1 | 99.9 | 99.9 | 53.2 | 98.5 | 35.8 | 27.6 | 25.1 | -0.1 | 5.80 | 5.10 | 3.70 |
| 422301 |  | 99.9 | 0 |  | 13.6 |  | 10.4 | 8.6 |  |  | 3.00 | 2.60 |
| 422303 | 5.7 | 10. | 0. |  | 23.6 |  | 18.4 | 1.1 | 0.3 |  | 0.14 | 0.10 |
| 422304 | -0.1 | 2300. | 0 |  | 61.5 |  | 27.6 | 40.4 | 0.1 |  | 4.40 | 1.30 |
| 420801 |  | 99.9 | 99.9 |  | 34.6 |  | 4.2 | 5.8 |  |  | 1.30 | 1.50 |
| 420802 |  | 4830. | 0 | 16.3 |  |  | 1.7 | 17.6 | 17.3 |  | 1.80 | 1.50 |
| 420803 | -0.1 | 54 | 0. |  | 11.0 |  |  | 6.2 | 0.1 |  | 0.32 | 0.25 |
| 420804 | -0.1 | 99.9 | 0. |  | 58.1 |  | 13.7 | 9.6 | -0.1 |  | 0.84 | 0.64 |
| 420901 |  | 99.9 | 2600. |  |  |  | 20.0 | 9.0 |  |  | 1.50 | 2.20 |
| 420902 |  | 400. | 0. | 20.4 |  |  | 4.4 | 18.0 | -0.1 |  | 5.00 | 5.00 |
| 420903 | 31.6 | 99.9 | 0. |  | 23.2 |  | 13.7 | 18.1 | -0.1 |  | 0.06 | 0.04 |
| 420904 | -0.1 | 99.9 | 54. |  | 43.8 |  | 17.0 | 18.6 | -0.1 |  | 4.50 | 3.50 |

(Continued)

TABLE B-1. Continued

| SAMPLE NUMBER | SO4 MG/L-SO4 | AL MG/L-AL | AS UG/L-AS | B UG/L-B | CD UG/L-CD | CA MG/L-CA | CO UG/L-CO | CR UG/L-CR | CU UG/L-CU | FE MG/L-FE | PB UG/L-PB | MG MG/L-MG | MN MG/L-MN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 416002 | 5 | 0.8 | -20 | 31 | -50. | 6 | -100 | -50. | -20. | -0.2 | -100. | 1.1 | -0.05 |
| 416003 | 4. | 0.4 | -10. | 248 | -20. | 4. | -50. | -20 | -50. | -0.1 | -200. | 1.7 | -0.05 |
| 410301 | | 6.6 | 10. | 120 | -20. | 3 | -50. | -20. | -20. | 10.2 | -100. | 0.5 | 0.34 |
| 410302 | 12. | 1.0 | -20. | 4 | -50 | | -100. | -50. | -20. | 0.2 | 100. | 0.3 | 0.02 |
| 410303 | 12 | 2.0 | -10 | 258 | -20 | | -50. | -20. | -50. | -0.1 | -200. | -1.0 | 0.22 |
| 410304 | 13 | 1.8 | -5. | 80 | | 1. | | -20. | -20. | -0.2 | | 0.4 | 0.22 |
| 410201 | | 1.2 | -10 | 60. | -20. | 4. | -50. | -20 | -20. | 1.1 | -100. | 1.7 | -0.05 |
| 410101 | | 0.8 | -10. | 40. | -20 | 3. | -50 | -20. | -20. | 0.7 | -100. | 1.4 | -0.05 |
| 410103 | 3 | -0.3 | -10 | 280 | 23. | 2 | -50 | -20 | -50 | 0.2 | -200. | 1.5 | -0.05 |
| 410104 | 4 | -0.5 | -5 | 62. | | 4. | | -20. | -20. | -0.2 | | 1.8 | 0.04 |
| 425601 | | 0.8 | -10 | 460. | -20. | 12. | -50. | -20. | 47. | 2.4 | -100. | 4.0 | -0.05 |
| 425602 | 26. | 0.7 | -20 | 34 | -50. | 10. | -100. | -50 | 72. | 1.0 | -100. | 2.7 | 0.09 |
| 425603 | 13. | -0.3 | -10. | 347. | -20. | 12. | -50. | 26. | 58. | 1.3 | -200. | 5.5 | -0.05 |
| 425604 | 4. | -0.5 | -5 | 404. | | 13. | | -20. | 56. | 1.1 | | 4.2 | 0.04 |
| 422301 | | -0.5 | 21 | 400 | -20. | 23. | -50. | -20. | -20. | 19.9 | -100. | 4.1 | 0.08 |
| 422303 | 4. | -0.3 | 29. | 92 | -20. | 12 | -50 | -20. | -50. | 27.0 | -200. | 6.4 | 0.14 |
| 422304 | 4. | -0.5 | 8 | 464 | | 12. | | -20 | -20. | 25.1 | | 2.1 | 0.12 |
| 420801 | | 0.6 | 23 | 440 | -20 | 28. | -50. | -20 | 30. | 7.7 | -100 | 5.1 | 0.13 |
| 420802 | 64. | 0.9 | -20 | 378 | -50. | 28. | -100. | -50 | 20. | 2.3 | -100. | 11.0 | 0.24 |
| 420803 | 26 | 0.6 | 17. | 187. | -20 | 4. | -50 | -20. | -50. | 1.2 | -200. | 16.0 | 0.24 |
| 420804 | 7. | -0.5 | 31. | 362. | | 7. | | -20 | 143. | 5.6 | | | 0.14 |
| 420901 | | -0.5 | -10. | 470 | -20 | 35 | -50. | -20. | -20. | 7.2 | -100. | 6.6 | 0.16 |
| 420902 | 4. | -0.3 | -20. | 424 | -50. | 15. | -100. | -50. | -20. | 6.8 | -100. | 3.8 | 0.15 |
| 420903 | 7. | -0.3 | -10. | 494. | -20. | 11. | -50. | -20 | -50 | 7.3 | -200. | 4.2 | 0.14 |
| 420904 | 26. | -0.5 | -5. | 362. | | 19. | | -20. | -20. | 7.5 | | 3.5 | 0.13 |

(Continued)

TABLE B-1. Continued

| SAMPLE NUMBER | HG UG/L-HG | NI UG/L-NI | K MG/L-K | NA MG/L-NA | ZN UG/L-ZN | SE UG/L-SE | ENDRIN NG/L | LINDANE NG/L | METHOXY-CHLOR NG/L | TOXA-PHENE NG/L | 2,4-D NG/L | 2,4,5 TP SILVEX NG/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 416002 | -1.0 | -50. | 1.6 | 3.9 | 29. | -10. | -0.03 | -1.1 | -0.01 | -0.1 | -2.1 | 60.0 |
| 416003 | -0.5 | -100. | 1.6 | 2.9 | -20. | -10. | -0.03 | 4.2 | -0.01 | -0.1 | -0.1 | 49.0 |
| 410301 | -1.0 | -50. | 0.5 | 1.4 | 99. | -10. | -0.03 | 2.2 | -0.01 | -0.1 | -54. | 21.0 |
| 410302 | -1.0 | -50. | 0.4 | 1.4 | 32. | -10. | -0.03 | 4.1 | -0.01 | -0.1 | -2.1 | 20.5 |
| 410303 | -0.5 | 133. | -0.5 | 1.1 | 34. | -10. | -0.03 | 0.4 | -0.01 | -0.1 | -0.1 | 133. |
| 410304 |  | -50. | -1.0 | -1.0 | 62. |  | -0.03 | 26.0 | -0.01 | -0.1 | -0.6 | 17.2 |
| 410201 | -1.0 | -50. | 2.9 | 2.3 | -20. | -10. | -0.03 | 8.8 | -0.01 | -0.1 | -54. | 16.5 |
| 410101 | -1.0 | -50. | 1.3 | 2.7 | -20. | -10. | -0.03 | 70.4 | -0.01 | -0.1 | -54. | 25.5 |
| 410103 | -0.5 | -100. | 2.1 | 2.3 | -20. | -10. | -0.03 | 0.6 | -0.01 | -0.1 | -0.1 | 22.9 |
| 410104 |  | -50. | 1.7 | 2.3 | 84. |  | -0.03 | 57.8 | -0.01 | -0.1 | -0.6 | 23.0 |
| 425601 | -1.0 | -50. | 26.3 | 117. | 113. | -10. | -0.03 | 10300. | -0.01 | -0.1 | -54. | 126. |
| 425602 | -1.0 | -50. | 10.4 | 45. | 146. | -10. | -0.03 | 260. | -0.01 | -0.1 | -2.1 | 109. |
| 425603 | -0.5 | -100. | 11.6 | 39. | 111. | -10. | -0.03 | 120. | -0.01 | -0.1 | 0.5 | 6.8 |
| 425604 |  | -50. | 9.8 | 38. | 136. |  | -0.03 | 642. | -0.01 | -0.1 |  | 44.8 |
| 422301 | -1.0 | -50. | 14.5 | 50. | 73. | -10. | -0.03 | 312. | -0.01 | -0.1 | -54. | 62.0 |
| 420802 | -1.0 | 91. | 16.1 | 55. | 3428. | -10. | -0.03 | 95.3 | -0.01 | -0.1 | -2. | 27.0 |
| 422303 | -0.5 | -100. | 6.7 | 39. | 34. | -10. | -0.03 | 96.0 | -0.01 | -0.1 | 0.3 | 42.5 |
| 422304 |  | -50. | 13.0 | 48. | -20. |  | -0.03 | 229. | -0.01 | -0.1 | 8.1 | 6.2 |
| 420801 | -1.0 | 119. | 12.8 | 27. | 964. | -10. | -0.03 | 13.7 | -0.01 | -0.1 | -54. | 10.5 |
| 420803 | -0.5 | 322. | 11.8 | 36. | 3365. | -10. | -0.03 | -0.2 | -0.01 | -0.1 | 11.6 | 63.2 |
| 420804 |  | 159. | 6.6 | 45. | 948. |  | -0.03 | 550. | -0.01 | -0.1 | 8.5 | 22.6 |
| 420901 | -1.0 | -50. | 16.3 | 55. | -20. | -10. | -0.03 | 4250. | -0.01 | -0.1 | -54 | 7.0 |
| 420902 | -1.0 | -50. | 12.6 | 51. | 32. | -10. | -0.03 | 526. | -0.01 | -0.1 | -2.1 | 27.2 |
| 420903 | -0.5 | -100. | 9.4 | 45. | -20. | -10. | -0.03 | 520. | -0.01 | -0.1 | -0.1 | 22.3 |
| 420904 |  | -50. | 9.3 | 24. | 48. |  | -0.03 |  | -0.01 | -0.1 | 10.2 | 42.6 |

(Continued)

TABLE B-1. Continued

| SAMPLE NUMBER | COLLECTION DATE | DEPTH M | TEMP DEG C | DISSOLVED OXYGEN MG/L | PH | CONDUC-TIVITY UMHOS/CM | TOTAL ALKALINITY MG/L CACO3 | DISSOLVED SOLIDS MG/L | SUSPENDED SOLIDS MG/L | TOTAL SOLIDS MG/L | VOLATILE SUSPENDED SOLIDS MG/L | BOD MG/L | COD MG/L | CL MG/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 421001 | 8/24/76 | 6.1 | 1.7 | 0.3 | 6.7 | 549. | 196. | | | | | 9. | | 16. |
| 421002 | 12/12/76 | 6.1 | | -0.1 | 6.7 | 528. | 192. | 200. | | | | 2. | 12. | 34. |
| 421003 | 3/ 3/77 | 6.1 | 1.2 | 0.3 | 6.7 | 659. | 192. | 260. | | | | 4. | 20. | 35. |
| 421004 | 5/31/77 | 6.1 | 1.4 | 0.5 | 6.6 | 504. | 141. | 282. | | | | 12. | 21. | 26. |
| 421101 | 8/24/76 | 12.5 | 1.5 | 0.2 | 6.6 | 490. | 158. | | | | | 4. | 44. | 19. |
| 420601 | 8/24/76 | 17.7 | 1.4 | 0.1 | 6.7 | 151. | 46. | | | | | 3. | 31. | 3. |
| 420602 | 12/12/76 | 17.7 | | -0.1 | 6.9 | 246. | 76. | 89. | | | | -1. | 16. | 18. |
| 420603 | 3/ 3/77 | 17.7 | 1.6 | 0.4 | 6.9 | 150. | 70. | 100. | | | | 1. | 16. | 14. |
| 420604 | 5/31/77 | 17.7 | 1.4 | -0.1 | 6.6 | 271. | 90. | 116. | | | | 8. | 25. | 59. |
| 422601 | 8/25/76 | 1.8 | 1.9 | 0.4 | 6.7 | 399. | 116. | | | | | 3. | 32. | 17. |
| 422602 | 12/10/76 | 1.8 | | -0.1 | 6.6 | 516. | 152. | | | | | 12. | 16. | 28. |
| 422603 | 3/ 7/77 | 1.8 | 1.1 | -0.1 | 6.8 | 489. | 124. | 214. | | | | 12. | 27. | 10. |
| 422701 | 8/24/76 | 1.8 | 1.9 | 0.3 | 6.7 | 156. | 50. | | | | | 3. | 72. | 6. |
| 422703 | 3/ 3/77 | 1.8 | 1.4 | 0.3 | 6.4 | 283. | 64. | 200. | | | | 2. | 40. | 20. |
| 422801 | 8/24/76 | 7.9 | 1.3 | 2.5 | 6.8 | 539. | 192. | | | | | 7. | | 24. |
| 422803 | 3/ 4/77 | 7.9 | 1.4 | -0.1 | 6.9 | 630. | 284. | 282. | | | | 3. | 29. | 19. |
| 422804 | 5/26/77 | 7.9 | 1.1 | -0.1 | 7.0 | 590. | 271. | 196. | | | | 11. | 38. | 41. |
| 422901 | 8/24/76 | 14.0 | 1.3 | -0.1 | 6.7 | 470. | 150. | | | | | 1. | 28. | 21. |
| 422902 | 12/10/76 | 14.0 | | -0.1 | 6.9 | 586. | 220. | 209. | | | | 1. | 16. | 39. |
| 422903 | 3/ 3/77 | 14.0 | 1.6 | -0.1 | 6.9 | 600. | 240. | 202. | | | | 1. | 21. | 79. |
| 422904 | 5/29/77 | 14.0 | 1.2 | -0.1 | 7.0 | 522. | 231. | 177. | | | | 10. | 24. | 54. |
| 423501 | 8/24/76 | 12.2 | 1.2 | -0.1 | 6.4 | 568. | 214. | | | | | 2. | 28. | 27. |
| 423502 | 12/12/76 | 12.2 | | -0.1 | 6.8 | 602. | 268. | 158. | | | | 4. | 63. | 44. |
| 423503 | 3/ 4/77 | 12.2 | 1.5 | | 6.8 | 615. | 276. | 255. | | | | | 31. | 37. |
| 423504 | 5/29/77 | 12.2 | 1.2 | -0.1 | 6.8 | 545. | 243. | 198. | | | | 11. | 27. | 38. |

(Continued)

TABLE B-1. Continued

| SAMPLE NUMBER | SULFIDE-SULFUR MG/L-S | TOTAL COLIFORM #/100ML | FECAL COLIFORM #/100ML | TOTAL ORGANIC CARBON MG/L-C | DISSOLVED ORGANIC CARBON MG/L-C | TOTAL ORGANIC NITROGEN MG/L-N | SOLUBLE ORGANIC NITROGEN MG/L-N | NH4 MG/L-N | NO3 MG/L-N | TOTAL PHOSPHORUS MG/L-P | SOLUBLE PHOSPHORUS MG/L-P | SOLUBLE ORTHO-PHOSPHATE MG/L-P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 421001 | | 0. | 0. | | 9.0 | | 1.8 | 8.2 | | | 3.30 | 1.80 |
| 421002 | | 200. | 0 | | | | 5.1 | 26.7 | -0.1 | | 3.90 | 3.70 |
| 421003 | 13.8 | 800. | 0. | | 18.3 | | 0.1 | 10.2 | -0.1 | | 2.60 | 2.40 |
| 421004 | -0.1 | 99.9 | 27. | | 21.6 | | 18.1 | 18.3 | -0.1 | | 2.60 | 2.20 |
| 421101 | | 0. | 0. | | 7.5 | | 41.6 | 8.4 | | | 0.76 | 0.76 |
| 420601 | | 0. | 0. | | | | 14.5 | 0.5 | | | 0.09 | 0.06 |
| 420602 | | 100. | 0. | 11.0 | | | 8.3 | 12.1 | -0.1 | | 0.03 | -0.01 |
| 420603 | -0.1 | 0. | 0. | | 2.4 | | 0.1 | 3.7 | -0.1 | | 0.09 | 0.60 |
| 420604 | -0.1 | 0. | 0. | | 11.2 | | 5.2 | 6.9 | -0.1 | | 0.04 | 0.02 |
| 422601 | | 0. | 0. | | 10.8 | | 26.4 | 8.6 | | | 2.50 | 2.20 |
| 422602 | | 0. | 0. | | | | | 21.8 | -0.1 | | 3.90 | 3.90 |
| 422603 | 25.8 | 1. | 100. | | 17.1 | | | 13.2 | -0.1 | | 4.40 | 3.20 |
| 422701 | | 0. | 0. | | 18.6 | | 5.3 | -0.1 | | | | |
| 422703 | -0.1 | 0. | 0. | | 20.0 | | 0.6 | 0.5 | 0.5 | | 1.70 | 1.10 |
| 422801 | | 0. | 0. | | 7.6 | | 2.0 | 0.8 | | | 0.46 | 0.19 |
| 422803 | -0.1 | 0. | 0. | | 50.2 | | | 15.6 | -0.1 | | 0.06 | -0.01 |
| 422804 | -0.1 | 0. | 0. | | 18.2 | | 11.0 | 18.2 | -0.1 | | 0.04 | 0.02 |
| 422901 | | 0. | 0. | | 4.5 | | | 1.7 | | | 0.02 | -0.01 |
| 422902 | | 100. | 0. | 9.1 | | | 0.9 | 20.5 | -0.1 | | 0.02 | -0.01 |
| 422903 | -0.1 | 0. | 0. | | | | | 12.9 | -0.1 | | 0.10 | 0.10 |
| 422904 | -0.1 | 150. | 0. | | 18.1 | | 13.7 | 20.6 | -0.1 | | 0.03 | 0.02 |
| 423501 | | 0. | 0. | | 6.9 | | | 4.2 | | | 0.07 | -0.01 |
| 423502 | | 0. | 0. | 21.4 | | | 5.8 | 19.0 | -0.1 | | -0.01 | -0.01 |
| 423503 | -0.1 | 0. | 0 | | 10.5 | | 9.5 | 11.7 | -0.1 | | 0.05 | -0.01 |
| 423504 | -0.1 | 250. | 0. | | 17.2 | | 15.6 | 17.0 | -0.1 | | 0.03 | 0.02 |

(Continued)

TABLE B-1. Continued

| SAMPLE NUMBER | SO4 MG/L-SO4 | AL MG/L-AL | AS UG/L-AS | B UG/L-B | CD UG/L-CD | CA MG/L-CA | CO UG/L-CO | CR UG/L-CR | CU UG/L-CU | FE MG/L-FE | PB UG/L-PB | MG MG/L-MG | MN MG/L-MN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 421001 |  | -0.5 | -10 | 400. | -20 | 16. | -50. | -20. | -20 | 11.4 | -100. | 5.2 | 0.09 |
| 421002 | 13 | -0.3 | -20. | 501 | -50. | 8. | -100. | -50 | -20. | 9.1 | -100. | 3.4 | -0.05 |
| 421003 | 14 | -0.3 | -10. | 286 | -20. | 11. | -50. | -20. | -50 | 9.5 | -200. | 5.1 | 0.08 |
| 421004 | 82 | -0.5 | -5. | 305. |  | 20. |  | -20. | -20. | 12.6 |  | 6.1 | 0.13 |
| 421101 |  | 0.7 |  | 280 | -20. | 6. | -50. | -20 | -20. | 19.0 | -100. | 3.7 | 0.15 |
| 420601 |  | -0.5 | -10. | 160. | -20. | 3. | -50. | -20 | -20. | 15.6 | -100. | 0.9 | 0.08 |
| 420602 | 11. | -0.3 | -20. | 304. | -50. | 2. | -100. | -50. | -20. | 21.0 | -100. | 1.2 | 0.12 |
| 420603 | 3. | -0.3 | -10. | 68. | -20. |  | -50. | -20. | -50. | 27.0 | -200. | 2.1 | 0.08 |
| 420604 | 11. | -0.5 | 6. | 230. |  | 4. |  | -20. | -20. | 43.4 |  | 3.0 | 0.19 |
| 422601 |  | 0.9 | 10 | 250. | -20 | 9. | -50. | -20. | -20. | 8.1 | -100. | 3.5 | 0.08 |
| 422602 | 58. | -0.3 | -20 | 411. | -50. | 12. | -100. | -50. | -20. | 8.4 | -100. | 7.1 | 0.16 |
| 422603 | 67. | -0.3 | -10 | 286. | -20. | 14. | -50. | -20 | -50. | 9.0 | -200. | 12.0 | 0.13 |
| 422701 |  | 2.1 | 10. | 160. | -20. | 14 | -50. | -20. | -20. | 10.1 | -100. | 2.9 | 0.30 |
| 422703 | 40. | -0.3 | -10. | 321. | -20. | 19. | -50. | -20. | -50. | 10.2 | -200. | 9.9 | 0.49 |
| 422801 |  | -0.5 | -10. | 350. | -20. | 80. | -50. | -20. | -20. | 36.0 | -100. | 4.8 | 0.31 |
| 422803 | 4. | 0.3 | 14. | 462. | -20. | 6. | -50. | 21. | -50. | 49.0 | -200. | 7.9 | 0.40 |
| 422804 | 4. | -0.5 | 8. | 336 |  | 8. |  | -20. | -20. | 56.0 |  | 2.2 | 0.09 |
| 422901 |  | -0.5 | -10. | 390 | -20. | 12. | -50. | -20. | -20. | 47.0 | -100. | 3.5 | 0.31 |
| 422902 | 12. | 0.5 | -20. | 506. | -50. | 4. | -100. | -50. | -20. | 27.0 | -100. | 3.4 | 0.36 |
| 422903 | 11. | -0.3 | -10. | 559. | -20. | 3. | -50. | -20. | -50. | 53.0 | -200. | 4.9 | 0.36 |
| 422904 | 11. | -0.5 | -5. | 474. |  | 5. |  | -20. | -20. | 50.8 |  | 3.3 | 0.35 |
| 423501 |  | -0.5 | -10. | 330. | -20. | 12. | -50. | -20. | -20. | 55.0 | -100. | 6.3 | 0.54 |
| 423502 | 22. | 0.7 | -20. | 283 | -50. | 7. | -100. | -50. | -20. | 28.0 | -100. | 5.9 | 0.68 |
| 423503 | 22. | -0.3 | -10. | 376. | -20. | 6. | -50. | -20. | -50. | 58.0 | -200. | 7.3 | 0.59 |
| 423504 | 31. | -0.5 | -5. | 306. |  | 9. |  | -20. | -20. | 59.9 |  | 5.7 | 0.55 |

(Continued)

TABLE B-1. Continued

| SAMPLE NUMBER | HG UG/L-HG | NI UG/L-NI | K MG/L-K | NA MG/L-NA | ZN UG/L-ZN | SE UG/L-SE | ENDRIN NG/L | LINDANE NG/L | METHOXY-CHLOR NG/L | TOXA-PHENE NG/L | 2,4-D NG/L | 2,4,5 TP SILVEX NG/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 421001 | -1.0 | -50. | 11.6 | 47. | -20. | -10. | -0.03 | 480. | -0.01 | -0.1 | -54. | 21.0 |
| 421002 | -1.0 | -50. | 15.2 | 55. | 28. | -10. | -0.03 | 158 | -0.01 | -0.1 | -2.1 | 28.7 |
| 421003 | -0.5 | -100. | 13.0 | 63. | -20. | -10. | -0.03 | 101. | -0.01 | -0.1 | 0.6 | 8.5 |
| 421004 |  | -50. | 13.0 | 50. | -20. |  | -0.03 |  | -0.01 | -0.1 | 70.1 | 101. |
| 421101 | -1.0 | -50. | 7.9 | 48. | -20. |  | -0.03 | 20. | -0.01 | -0.1 | -54. | 9.0 |
| 420601 | -1.0 | -50. | 5.0 | 4.4 | -20. | -10. | -0.03 | 18.4 | -0.01 | -0.1 | -54. | -5.4 |
| 420602 | -1.0 | -50. | 5.7 | 15. | -20. | -10. | -0.03 | 20.2 | -0.01 | -0.1 | -2.1 | 8.4 |
| 420603 | -0.5 | -100. | 7.9 | 6.2 | -20. | -10. | -0.03 | 1.5 | -0.01 | -0.1 | 14.3 | 36.6 |
| 420604 |  | -50. | 6.6 | 24. | 25. |  | -0.03 | 35.8 | -0.01 | -0.1 | 23.9 | 17.3 |
| 422601 | -1.0 | -50. | 8.7 | 29. | 22. | -10. | -0.03 | 122. | -0.01 | -0.1 | -54. | 51.6 |
| 422602 | -1.0 | -50. | 12.3 | 36. | -20. | -10. | -0.03 | 80. | -0.01 | -0.1 | -2.1 | 63.8 |
| 422603 | -0.5 | -100. | 9.0 | 28. | -20. | -10. | -0.03 | 1340. | -0.01 | -0.1 | -0.1 | 30.7 |
| 422701 | -1.0 | -50. | 5.4 | 10. | 30. | -10. | -0.03 | 28. | -0.01 | -0.1 | -54. | 57.2 |
| 422703 | -0.5 | -100. | 5.1 | 14. | 92. | -10. | -0.03 | 18.2 | -0.01 | -0.1 | 0.2 | 15.4 |
| 422801 | -1.0 | -50. | 12.2 | 69. | 105. | -10. | -0.03 | 8.2 | -0.01 | -0.1 | -54. | 42.2 |
| 422803 | -0.5 | -100. | 11.0 | 50. | -20. | -10. | -0.03 | 510. | -0.01 | -0.1 | -0.1 | 62.3 |
| 422804 |  | -50. | 11.7 | 89. | -20. |  | -0.03 | 69.6 | -0.01 | -0.1 | 5.3 | 9.8 |
| 422901 | -1.0 | -50. | 11.3 | 42. | 116. | -10. | -0.03 | 1.8 | -0.01 | -0.1 | -54. | 54.0 |
| 422902 | -1.0 | -50. | 10.4 | 54. | -20. | -10. | -0.03 | 6.7 | -0.01 | -0.1 | -2. | 38.4 |
| 422903 | -0.5 | -100. | 9.8 | 46. | 34. | -10. | -0.03 | 32.1 | -0.01 | -0.1 | -0.1 | 20.3 |
| 422904 |  | -50. | 9.8 |  | -20. |  | -0.03 | 29.6 | -0.01 | -0.1 | 47.9 | 5.9 |
| 423501 | -1.0 | -50. | 11.4 | 52. | 100. | -10. | -0.03 | 8.0 | -0.01 | -0.1 | -54. | 60.0 |
| 423502 | -1.0 | -50. | 9.3 | 62. | 32. | -10. | -0.03 | 18. | -0.01 | -0.1 | -2.1 | 31.9 |
| 423503 | -0.5 | -100. | 9.8 | 53. | -20. | -10. | -0.03 | 8.0 | -0.01 | -0.1 | -0.1 | 21.5 |
| 423504 |  | -50. | 9.3 | 48. | -20. |  | -0.03 | 30. | -0.01 | -0.1 | 23.5 | 8.8 |

(Continued)

TABLE B-1. Continued

| SAMPLE NUMBER | COLLECTION DATE | DEPTH M | TEMP DEG C | DISSOLVED OXYGEN MG/L | PH | CONDUC-TIVITY UMHOS/CM | TOTAL ALKALINITY MG/L CACO3 | DISSOLVED SOLIDS MG/L | SUSPENDED SOLIDS MG/L | TOTAL SOLIDS MG/L | VOLATILE SUSPENDED SOLIDS MG/L | BOD MG/L | COD MG/L | CL MG/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 423101 | 8/24/76 | 3.0 | 1.6 | 0.4 | 6.4 | 196. | 80. | | | | | 2. | 50. | 12. |
| 423102 | 12/12/76 | 3.0 | | -0.1 | 6.8 | 270 | 118. | 57. | | | | 2. | 138. | 22 |
| 423103 | 3/ 4/77 | 3.0 | 1.0 | -0.1 | 6.9 | 310. | 140. | 203. | | | | 4. | 48. | 26. |
| 423001 | 8/24/76 | 0.9 | 2.1 | -0.1 | 5.9 | 56. | 10 | | | | | 3. | 36 | 3. |
| 425501 | 8/26/76 | | | 1.7 | 5.5 | 425 | 88. | 186. | 54 | 240. | 11 | 142. | | 19. |
| 425502 | 12/12/76 | | | 2.2 | 7.0 | 516 | 136. | 222. | 34. | 256. | 44. | 145. | 272 | 34. |
| 425503 | 3/ 7/77 | | 0.8 | 3.3 | 7.5 | 464 | 146 | 281. | 38. | 319. | | 136. | 273. | 77 |
| 425504 | 5/27/77 | | | -0.1 | 7.2 | 1001 | 149. | 514. | 39. | 553. | 32. | 173. | 315. | 179. |
| 422201 | 8/24/76 | 2.1 | 2.2 | 2.7 | 6.9 | 686. | 192. | | | | | 6. | 69. | 21. |
| 422203 | 3/ 9/77 | 2.1 | 1.4 | 1.2 | 6.8 | 856. | 264. | 245. | | | | 5. | 33. | 43. |
| 422204 | 5/29/77 | 2.1 | 1.3 | 0.3 | 6.4 | 528. | 175. | 314. | | | | 12. | | 33. |
| 421701 | 8/23/76 | 0.6 | 2.7 | -0.1 | 7.2 | 576. | 176. | | | | | 11. | 70. | 17. |
| 421703 | 3/ 8/77 | 0.6 | 1.0 | -0.1 | 6.8 | 966. | 236. | 530. | | | | 15. | 157. | 156. |
| 421801 | 8/23/76 | 1.2 | 2.6 | -0.1 | 7.0 | 588. | 164. | | | | | 26. | 104. | 35. |
| 421802 | 12/11/76 | 1.2 | | -0.1 | 6.6 | 429. | 152. | 180. | | | | 8. | 132. | 36. |
| 421803 | 3/ 8/77 | 1.2 | 0.9 | -0.1 | 6.8 | 1136 | 242. | 615 | | | | 22. | 248. | 198 |
| 421804 | 5/30/77 | 1.2 | | 0.1 | 6.4 | 972. | 162. | 421. | | | | 12. | 54 | 164. |
| 420401 | 8/23/76 | 1.8 | 2.6 | 1.9 | 7.7 | 539 | 178. | | | | | 24. | | 16. |
| 421901 | 8/23/76 | 2.7 | 2.6 | -0.1 | 7.1 | 413. | 144. | | | | | 11. | | 16. |
| 421902 | 12/11/76 | 2.7 | | -0.1 | 6.6 | 258. | 168. | 231. | | | | 7. | 66. | 52. |
| 421903 | 3/ 8/77 | 2.7 | 0.6 | -0.1 | 6.8 | 1050. | 228. | 564. | | | | 15. | 246. | 160. |
| 421904 | 5/29/77 | 2.7 | | -0.1 | 6.5 | 762. | 149. | 415. | | | | 11. | 61 | 122. |
| 422001 | 8/23/76 | 4.1 | 2.7 | 0.2 | 7.4 | 490. | 164. | | | | | 8. | 69. | 18. |
| 420301 | 8/23/76 | 7.9 | 2.6 | 0.3 | 6.7 | 519. | 164. | | | | | 10. | 53. | 16. |
| 420302 | 12/12/76 | 7.7 | | 0.3 | 6.8 | 708. | 216. | 271. | | | | 15. | 181. | 74 |

(Continued)

TABLE B-1. Continued

| SAMPLE NUMBER | SULFIDE-SULFUR MG/L-S | TOTAL COLIFORM #/100ML | FECAL COLIFORM #/100ML | TOTAL ORGANIC CARBON MG/L-C | DISSOLVED ORGANIC CARBON MG/L-C | TOTAL ORGANIC NITROGEN MG/L-N | SOLUBLE ORGANIC NITROGEN MG/L-N | NH4 MG/L-N | NO3 MG/L-N | TOTAL PHOSPHORUS MG/L-P | SOLUBLE PHOSPHORUS MG/L-P | SOLUBLE ORTHO-PHOSPHATE MG/L-P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 423101 | | 99.9 | 0. | | 20.3 | | | 16.0 | | | 1.10 | -0.01 |
| 423102 | | 0 | 0 | 26.2 | | | 3.1 | 6.9 | -0.1 | | 0.02 | -0.01 |
| 423103 | -0.1 | 0. | 0. | | 18.2 | | | 3.5 | -0.1 | | 0.57 | 0.02 |
| 423001 | | 99.9 | 0 | | 11.8 | | | -0.1 | | | 1.50 | 0.08 |
| 425501 | | 99.9 | 99.9 | 56.4 | 40.5 | | 22.0 | 20.0 | | 12.5 | 7.20 | 4.00 |
| 425502 | | 99.9 | 99.9 | 79.2 | 55.6 | 19.9 | 15.9 | 18.3 | 3.7 | 6.50 | 5.40 | 3.50 |
| 425503 | 0.1 | 99.9 | 0. | 76.0 | 42.9 | 0.7 | | 13.8 | -0.1 | 8.60 | 6.30 | 5.70 |
| 425504 | -0.1 | 99.9 | 99.9 | 15.6 | 53.0 | 34.8 | 25.4 | 23.7 | -0.1 | 8.50 | 6.40 | 5.90 |
| 422201 | | 0. | 0. | | 21.0 | | | 7.0 | | | 2.00 | 0.31 |
| 422203 | 7.0 | 3. | 0. | | 23.4 | | | 24.8 | -0.1 | | 0.69 | 0.53 |
| 422204 | -0.1 | 150. | 0. | | 27.0 | | 19.0 | 22.3 | 0.5 | | 0.27 | 0.23 |
| 421701 | | 99.9 | 1000. | | 21.9 | | | 21.0 | | | 3.80 | 2.20 |
| 421703 | 31.6 | 99.9 | 0 | | 43.2 | | | 20.5 | -0.1 | | 6.70 | 5.80 |
| 421801 | | 99.9 | 99.9 | | | | | 19.0 | | | 3.00 | 2.10 |
| 421802 | | 7000. | 450. | | | | 0.4 | 14.2 | 0.1 | | 5.70 | 5.50 |
| 421803 | 45.2 | 99.9 | 16. | | 76.6 | | 0.8 | 27.3 | -0.1 | | 5.50 | 5.50 |
| 421804 | -0.1 | 6150. | 0. | | 15.5 | | 12.1 | 15.6 | -0.1 | | 2.90 | 2.80 |
| 420401 | | 0. | 0. | | -1.0 | | | 17.0 | | | 2.40 | 2.40 |
| 421901 | | 2400. | 200. | | 11.3 | | | 14.0 | | | 2.00 | 1.80 |
| 421902 | | 99.9 | 1096. | 23.9 | | | | 17.4 | 0.1 | | 4.70 | 3.40 |
| 421903 | 49.7 | 99.9 | 234 | | 84.0 | | | 24.4 | -0.1 | | 5.80 | 5.50 |
| 421904 | 0.4 | 0 | 0. | | 17.6 | | 16.3 | 19.4 | -0.1 | | 4.00 | 3.80 |
| 422001 | | 3100. | 0. | | 10.9 | | | 15.0 | | | 4.70 | 2.00 |
| 420301 | | 0. | 0. | | 17.2 | | | 15.0 | | | 4.20 | 2.20 |
| 420302 | | 99.9 | 300. | 29.2 | | | 19.1 | 16.1 | -0.1 | | 5.60 | 5.00 |

(Continued)

TABLE B-1. Continued

| SAMPLE NUMBER | SO4 MG/L-SO4 | AL MG/L-AL | AS UG/L-AS | B UG/L-B | CD UG/L-CD | CA MG/L-CA | CO UG/L-CO | CR UG/L-CR | CU UG/L-CU | FE MG/L-FE | PB UG/L-PB | MG MG/L-MG | MN MG/L-MN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 423101 |  | 1.2 | -10 | 260 | -20 | 7. | -50. | -20. | -20. | 28.0 | -100. | 1.7 | 0.30 |
| 423102 | 4 | 1.1 | -20 | 469 | -50. | 2. | -100. | -50 | -20. | 24.0 | -100. | 2.6 | 0.38 |
| 423103 |  | 0.3 | -10. | 234 | -20. | 1. | -50. | -20. | -50. | 39.0 | -200 | 3.8 | 0.36 |
| 423001 |  | 15.3 |  | 160. | -20. | 2. | -50. | 50. | -20. | 16.4 | -100 | 0.5 | 0.18 |
| 425501 |  | -0.5 | -10 | 350. | -20. | 13. | -50. | -20. | 54. | 2.9 | -100. | 4.0 | -0.05 |
| 425502 | 32 | 0.9 | -20 | 610 | -50 | 11. | -100. | -50. | 96. | 0.7 | -100. | 3.0 | 0.09 |
| 425503 | 23. | -0.3 | 10. | 642. | -20 | 8. | -50. | -20. | 92. | 0.7 | -200. | 5.3 | 0.10 |
| 425504 | 17. | -0.5 | 5 | 534. |  | 11. |  | -20. | 65. | 0.6 |  | 3.9 | 0.03 |
| 422201 |  | -0.5 | -10 | 500. | -20. | 10. | -50. | -20. | -20. | 20.0 | -100. | 3.6 | 0.11 |
| 422203 | 7. | -0.3 | -10. | 509. | -20 | 6. | -50. | -20. | -50. | 24.0 | -200. | 6.2 | 0.13 |
| 422204 | 80. | -0.5 | -5. | 416. |  | 28. |  | -20. | -20. | 21.3 |  | 7.2 | 0.37 |
| 421701 |  | 1.4 | -10. | 600. | -20. | 8. | -50. | -20. | -20. | 4.7 | -100. | 3.0 | 0.06 |
| 421703 | 10. | -0.3 | -10. | 639. | -20. | 11. | -50. | -20. | -50. | 9.1 | -200. | 3.7 | 0.06 |
| 421801 |  | 1.5 | -10. | 480. | -20 | 10. | -50. | -20. | -20. | 3.3 | -100. | 3.9 | -0.05 |
| 421802 | 12. | -0.3 | -20. | 759. | -50. | 2. | -100. | -50. | -20. | 0.6 | -100. | 0.4 | -0.05 |
| 421803 | 12. | -0.3 | -10. | 359 | -20. | 5. | -50. | -20. | -50. | 4.7 | -200. | 6.2 | 0.11 |
| 421804 | 8. | -0.5 | 5. | 654 |  | 22. |  | -20. | -20. | 10.7 |  | 11.0 | 0.16 |
| 420401 |  | 1.2 | -10. | 470 | -20. | 8. | -50. | -20. | -20. | 3.0 | -100. | 3.1 | -0.05 |
| 421901 |  | -0.5 | -10. | 530. | -20. | 8. | -50. | -20. | -20. | 3.0 | -100. | 2.3 | -0.05 |
| 421902 | 31. | -0.3 | -20. | 933. | -50. | 5. | -100. | -50. | 63. | 1.1 | -100. | 1.3 | 0.11 |
| 421903 | 8 | -0.3 | -10 | 446. | -20. | 6 | -50. | -20. | -50. | 5.7 | -200. | 8.6 | 0.06 |
| 421904 | 118. | -0.5 | -5. | 505. |  | 22. |  | -20 | -20. | 15.0 |  | 10.0 | 0.12 |
| 422001 |  | -0.5 |  | 650. | -20. | 8. | -50. | -20. | -20. | 3.8 | -100. | 3.0 | -0.05 |
| 420301 |  | 1.6 | 13. | 600. | -20. | 10. | -50. | -20. | -20. | 10.3 | -100. | 2.9 | 0.05 |
| 420302 | 5. | -0.3 | -20 | 727 | -50. | 11. | -100 | -50. | 20. | 12.0 | -100. | 3.5 | 0.12 |

(Continued)

TABLE B-1. Continued

| SAMPLE NUMBER | HG UG/L-HG | NI UG/L-NI | K MG/L-K | NA MG/L-NA | ZN UG/L-ZN | SE UG/L-SE | ENDRIN NG/L | LINDANE NG/L | METHOXY-CHLOR NG/L | TOXA-PHENE NG/L | 2,4-D NG/L | 2,4,5 TP SILVEX NG/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 423101 | -1.0 | -50. | 7.2 | 21. | 83. | -10. | -0.03 | 112. | -0.01 | -0.1 | -54. | 42.9 |
| 423102 | -1.0 | -50. | 7.5 | 27. | -20. | -10. | -0.03 | 26. | -0.01 | -0.1 | -2.1 | 4.4 |
| 423103 | -0.5 | -100. | 7.7 | 28. | -50. | -10. | -0.03 | 18. | -0.01 | -0.1 | -0.1 | 93.5 |
| 423001 | -1.0 | -50. | 3.5 | 3.8 | 83. |  | -0.03 | 290. | -0.01 | -0.1 | -54. | 64.3 |
| 425501 | -1.0 | -50. | 9.3 | 34. | 207. | -10. | -0.03 | 4510. | -0.01 | -0.1 | -54. | 131. |
| 425502 | -1.0 | -50. | 11.0 | 68. | 113. | -10. | -0.03 | 8.8 | -0.01 | -0.1 | -2.1 | 52.8 |
| 425503 | -0.5 | -100. | 9.8 | 51. | 72. | -10. | -0.03 | 0.5 | -0.01 | -0.1 | 3.5 | 72.3 |
| 425504 |  | -50. | 11.3 | 145. | 92. |  | -0.03 | 388. | -0.01 | -0.1 |  | 35. |
| 422201 | -1.0 | -50. | 15.3 | 43. | -20 | -10. | -0.03 | 80. | -0.01 | -0.1 | -54. | -5.4 |
| 422203 | -0.5 | -100. | 9.0 | 54. | -20 | -10. | -0.03 | 5.7 | -0.01 | -0.1 | -0.1 | 26.6 |
| 422204 |  | -50. | 11.0 | 35. | -20. |  | -0.03 | 1340. | -0.01 | -0.1 | 10.8 | 6.2 |
| 421701 | -1.0 | -50. | 13.6 | 49. | -20. | -10. | -0.03 | 1700. | -0.01 | -0.1 | -54. | 29.0 |
| 421703 | -0.5 | -100. | 13.4 | 146. | 92. | -10. | -0.03 | 648. | -0.01 | -0.1 | -0.1 | 29.0 |
| 421801 | -1.0 | -50. | 13.2 | 44. | -20. | -10. | -0.03 | 625. | -0.01 | -0.1 | -54. | 66.0 |
| 421802 | -1.0 | -50. | 4.8 | 53. | -20. | -10. | -0.03 | 2960. | -0.01 | -0.1 | -2.1 | 19.6 |
| 421803 | -0.5 | -100. | 14.6 | 167. | -20. | -10. | -0.03 | 1100. | -0.01 | -0.1 | -0.1 | 144. |
| 421804 |  | -50. | 17.2 | 188 | 50. |  | -0.03 | 1840. | -0.01 | -0.1 | 35.8 | 14.0 |
| 420401 | -1.0 | -50. | 15.0 | 56. | 56. | -10. | -0.03 | 880. | -0.01 | -0.1 | -54. | 16.0 |
| 421901 | -1.0 | -50. | 9.3 | 33. | -20 | -10. | -0.03 | 1900. | -0.01 | -0.1 | -54. | 180. |
| 421902 | -1.0 | -50. | 13.6 | 74. | -20. | -10. | -0.03 |  | -0.01 | -0.1 |  |  |
| 421903 | -0.5 | -100. | 15.0 | 154. | -20. | -10. | -0.03 | 6480. | -0.01 | -0.1 | -0.1 | 17.2 |
| 421904 |  | -50. | 18.0 | 169. | 25. |  | -0.03 | 234. | -0.01 | -0.1 | -0.6 | 45.5 |
| 422001 | -1.0 | -50. | 12.5 | 48. | -20. |  | -0.03 | 12. | -0.01 | -0.1 | -54. | 700. |
| 420301 | -1.0 | -50. | 14.8 | 47. | 309. | -10. | -0.03 | 1050. | -0.01 | -0.1 | -54. | 840. |
| 420302 | -1.0 | -50. | 14.2 | 92. | -20. | -10. | -0.03 | 1900. | -0.01 | -0.1 | -2.1 | 6.5 |

(Continued)

TABLE B-1. Continued

| SAMPLE NUMBER | COLLECTION DATE | DEPTH M | TEMP DEG C | DISSOLVED OXYGEN MG/L | PH | CONDUC-TIVITY UMHOS/CM | TOTAL ALKALINITY MG/L CACO3 | DISSOLVED SOLIDS MG/L | SUSPENDED SOLIDS MG/L | TOTAL SOLIDS MG/L | VOLATILE SUSPENDED SOLIDS MG/L | BOD MG/L | COD MG/L | CL MG/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 420303 | 3/ 8/77 | 7.9 | 0.7 | -0.1 | 6.9 | 1110. | 236. | 550. | | | | 20. | 155 | 187. |
| 420304 | 5/27/77 | 7.9 | | -0.1 | 6.7 | 517. | 200. | 254 | | | | 10. | 41 | 42 |
| 422101 | 8/23/76 | 15.5 | 1.8 | 0.3 | 6.5 | 770. | 156. | | | | | 5. | 32. | 53. |
| 422102 | 12/11/76 | 15.5 | | 0.2 | 6.7 | 580. | 172. | 278. | | | | 4. | 32. | 59. |
| 422103 | 3/ 7/77 | 15.5 | 1.4 | -0.1 | 6.9 | 756. | 192. | 324. | | | | 4 | 48. | 97. |
| 422104 | 5/27/77 | 15.5 | 1.4 | -0.1 | 6.9 | 614. | 211. | 320. | | | | 12 | 37. | 56. |
| 423701 | 8/24/76 | 2.1 | 1.9 | 0.4 | 6.4 | 588. | 152. | | | | | 5. | | 37. |
| 423702 | 12/10/76 | 2.1 | | -0.1 | 6.4 | 516. | 132. | 243. | | | | 5. | 36. | 62. |
| 423703 | 3/ 7/77 | 2.1 | 1.4 | 0.7 | 6.9 | 453. | 108. | 190. | | | | 4. | 33. | 20. |
| 423801 | 8/23/76 | 4.3 | 1.6 | -0.1 | 6.9 | 673. | 174. | | | | | 9. | 44. | 58. |
| 423803 | 3/ 5/77 | 4.3 | 1.5 | 1.1 | 6.9 | 615. | 192. | 340. | | | | 3. | 52 | 93. |
| 423901 | 8/23/76 | 9.1 | 1.5 | 2.5 | 6.8 | 673. | 194. | | | | | 3 | | 47. |
| 423903 | 3/ 5/77 | 9.1 | 1.6 | -0.1 | 7.0 | 720. | 204. | 368. | | | | 2. | 38. | 46. |
| 423904 | 5/27/77 | 9.1 | 1.6 | -0.1 | 6.8 | 725. | 196. | 399. | | | | 11. | 64. | 85. |
| 424001 | 8/23/76 | 15.2 | 1.5 | -0.1 | 6.7 | 770. | 192. | | | | | 3. | | 61. |
| 424002 | 12/10/76 | 15.2 | | -0.1 | 6.9 | 861. | 240. | 311. | | | | 1. | 20. | 105. |
| 424003 | 3/ 5/77 | 15.2 | 1.7 | 0.3 | 7.0 | 826. | 272. | 318. | | | | 2. | 29. | 106. |
| 424004 | 5/27/77 | 15.2 | 1.5 | -0.1 | 6.9 | 694. | 231. | 331. | | | | 6. | 32. | 104. |
| 423601 | 8/24/76 | 9.1 | 1.5 | -0.1 | 6.7 | 686. | 204. | | | | | 3. | | 47. |
| 423603 | 3/ 9/77 | 9.1 | 1.8 | -0.1 | 6.8 | 676. | 184. | | | | | 2. | 25. | 94. |
| 423604 | 5/30/77 | 9.1 | 1.4 | -0.1 | 6.8 | 591. | 208. | 7707. | | | | 11. | 132. | 107. |
| 410401 | 8/26/76 | 5.8 | 1.4 | 12.0 | 4.6 | 49. | 1. | | | | | -1. | | 1. |
| 410403 | 3/ 5/77 | 5.8 | 1.4 | 3.0 | 4.9 | 94. | 4. | 37. | | | | -1. | 3. | 10. |
| 410404 | 5/26/77 | 5.8 | 1.1 | 4.9 | 4.5 | 97. | -2. | 75. | | | | 1. | 6. | 19. |
| 410503 | 3/ 7/77 | 17.1 | 1.3 | 1.0 | 4.9 | 348. | 4. | 213. | | | | -1. | 8. | 53. |

(Continued)

TABLE B-1. Continued

| SAMPLE NUMBER | SULFIDE-SULFUR MG/L-S | TOTAL COLIFORM #/100ML | FECAL COLIFORM #/100ML | TOTAL ORGANIC CARBON MG/L-C | DISSOLVED ORGANIC CARBON MG/L-C | TOTAL ORGANIC NITROGEN MG/L-N | SOLUBLE ORGANIC NITROGEN MG/L-N | NH4 MG/L-N | NO3 MG/L-N | TOTAL PHOSPHORUS MG/L-P | SOLUBLE PHOSPHORUS MG/L-P | SOLUBLE ORTHO-PHOSPHATE MG/L-P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 420303 | 20.8 | 99.9 | 0. | | 45.9 | | 8.6 | 22.4 | -0.1 | | 7.10 | 6.70 |
| 420304 | 0.2 | 22. | 4. | | 28.5 | | 19.6 | 29.8 | -0.1 | | 7.60 | 7.30 |
| 422101 | | 0. | 0. | | 10.0 | | 7.4 | 3.6 | | | 3.00 | 1.90 |
| 422102 | | 0. | 0. | 18.1 | | | | 1.4 | 0.1 | | 6.00 | 5.00 |
| 422103 | -0.1 | 99.9 | 0. | | 18.0 | | | 11.9 | -0.1 | | 3.30 | 3.20 |
| 422104 | -0.1 | 8. | 0. | | 23.5 | | 15.0 | 25.4 | -0.1 | | 2.20 | 2.00 |
| 423701 | | 0. | 0. | | 11.5 | | 1.5 | -0.1 | | | 1.80 | 1.40 |
| 423702 | | 0. | 0. | 21.8 | | | 3.2 | 12.1 | -0.1 | | 2.00 | 1.00 |
| 423703 | 0.1 | 186. | 69. | | 12.8 | | | 5.1 | 1.6 | | 0.69 | 0.69 |
| 423801 | | 0. | 0. | | 14.6 | | | 14.5 | | | 0.62 | 0.08 |
| 423803 | 3.3 | 0. | 0. | | 17.6 | | | 14.5 | -0.1 | | 0.12 | 0.09 |
| 423901 | | 0. | 0. | | 13.3 | | 5.5 | 12.5 | | | 0.41 | 0.35 |
| 423903 | -0.1 | 0. | 0. | | 30.6 | | 5.6 | 17.1 | -0.1 | | 0.25 | 0.23 |
| 423904 | -0.1 | 0 | 0. | | 12.5 | | 12.5 | 21.4 | -0.1 | | 0.26 | 0.23 |
| 424001 | | 0. | 0. | | 7.0 | | | 7.8 | | | 0.76 | -0.01 |
| 424002 | | 33. | 0. | 9.0 | | | 2.1 | 21.3 | -0.1 | | -0.01 | -0.01 |
| 424003 | -0.1 | 0. | 0 | | 7.9 | | | 22.6 | -0.1 | | 0.03 | -0.01 |
| 424004 | -0.1 | 0. | 0. | | 7.3 | | 14.2 | 24.7 | -0.1 | | 0.02 | 0.02 |
| 423601 | | 0. | 0. | | 8.4 | | 9.6 | 7.4 | | | 0.19 | 0.08 |
| 423603 | 0.1 | 0. | 0. | | 8.5 | | | 14.4 | -0.1 | | 0.05 | 0.03 |
| 423604 | -0.1 | 0. | 0. | | 24.5 | | 8.8 | 19.2 | -0.1 | | 0.02 | 0.02 |
| 410401 | | 0. | 0. | | 18.9 | | | 2.7 | | | 0.10 | 0.02 |
| 410403 | -0.1 | 0. | 0. | | 1.1 | | 1.5 | 0.2 | 0.2 | | 0.04 | 0.03 |
| 410404 | -0.1 | 0. | 0. | | 2.5 | | 0.5 | 0.1 | 0.6 | | 0.02 | 0.02 |
| 410503 | -0.1 | 186. | 67. | | 3.2 | | 1.3 | 6.4 | 0.2 | | 0.06 | 0.04 |

(Continued)

TABLE B-1. Continued

| SAMPLE NUMBER | SO4 MG/L-SO4 | AL MG/L-AL | AS UG/L-AS | B UG/L-B | CD UG/L-CD | CA MG/L-CA | CO UG/L-CO | CR UG/L-CR | CU UG/L-CU | FE MG/L-FE | PB UG/L-PB | MG MG/L-MG | MN MG/L-MN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 420303 | 5 | -0.3 | -10 | 777 | -20. | 10 | -50. | -20 | -50. | 16.0 | -200 | 3.8 | 0.11 |
| 420304 | 9. | 0.6 | 8. | 517 | | 3. | | -20 | -20. | 9.7 | | 4.0 | 0.22 |
| 422101 | | 0.6 | 12. | 500 | -20. | 7. | -50. | -20. | -20. | 24.0 | -100. | 3.7 | 0.13 |
| 422102 | 6. | -0.3 | -20 | 664 | -50 | 5. | -100. | -50 | -20. | 13.4 | -100. | 1.5 | 0.11 |
| 422103 | | -0.3 | 15. | 559 | -20 | 7. | -50. | -20. | -50. | 18.0 | -200. | 4.7 | 0.08 |
| 422104 | 3. | -0.5 | 7 | 489. | | 9. | | -20 | -20 | 12.6 | | 1.9 | 0.08 |
| 423701 | | 0.6 | -10. | 460 | -20 | 13. | -50. | -20. | -20. | 7.9 | -100. | 2.1 | 0.26 |
| 423702 | 15. | -0.3 | -20. | 443 | -50. | 11. | -100 | -50 | -20. | 7.1 | -100. | 1.3 | 0.29 |
| 423703 | 44 | -0.3 | -10. | 664. | -20. | 27. | -50. | -20. | -50. | 7.2 | -200. | 7.5 | 0.28 |
| 423801 | | -0.5 | 14. | 500 | -20. | 5. | -50. | -20 | -20 | 10.7 | -100 | 2.8 | 0.54 |
| 423803 | 6. | 0.5 | 25. | 411. | -20. | 3. | -50. | -20. | -50. | 14.0 | -200. | 4.6 | 0.85 |
| 423901 | | 2.3 | 10. | 480. | -20. | 6. | -50. | -20. | -20. | 33.4 | -100. | 2.7 | 0.21 |
| 423903 | 4. | 0.7 | -10. | 505. | -20. | 3. | -50. | -20. | -50. | 31.0 | -200. | 4.2 | 0.18 |
| 423904 | 3. | -0.5 | 12. | 460. | | 5. | | -20. | -20. | 27.1 | | 2.8 | 0.18 |
| 424001 | | -0.5 | -10. | 490. | -20. | 7. | -50. | -20. | -20. | 51.9 | -100. | 3.4 | 0.18 |
| 424002 | 4. | -0.3 | -20. | 458. | -50 | 5. | -100. | -50. | -20. | 27.0 | -100. | 3.7 | 0.30 |
| 424003 | 3 | -0.3 | -10. | 444. | -20. | 4. | -50. | -20. | -50. | 54.0 | -200. | 4.7 | 0.22 |
| 424004 | 3 | -0.5 | -5 | 625. | | 6. | | -20. | -20. | 53.3 | | 4.0 | 0.22 |
| 423601 | | 8.9 | 37. | 380 | -20 | 12. | -50. | 44. | -20. | 36.0 | -100. | 6.2 | 0.14 |
| 423603 | 3. | 0.5 | -10 | 650 | -20. | 8. | -50. | -20. | -50. | 38.0 | -200. | 7.8 | 0.44 |
| 423604 | 4. | 1.4 | 7. | 343 | | 11. | | -20. | -20. | 39.0 | | 5.7 | 0.56 |
| 410401 | | 1.2 | -10. | 40. | -20. | 7. | -50. | -20 | -20. | 0.6 | -100. | 0.5 | 0.19 |
| 410403 | 9. | 0.4 | -10. | 52. | 26. | 2. | -50. | -20 | -50. | 0.2 | -200. | -1.0 | 0.28 |
| 410404 | 13. | 0.6 | -5. | | | 3. | | -20. | -20. | -0.2 | | 1.8 | 0.36 |
| 410503 | 3. | 0.4 | -10 | 65. | -20. | 4. | -50. | -20 | -50. | -0.1 | -200. | 6.0 | 0.08 |

(Continued)

TABLE B-1. Continued

| SAMPLE NUMBER | HG UG/L-HG | NI UG/L-NI | K MG/L-K | NA MG/L-NA | ZN UG/L-ZN | SE UG/L-SE | ENDRIN NG/L | LINDANE NG/L | METHOXY-CHLOR NG/L | TOXA-PHENE NG/L | 2,4-D NG/L | 2,4,5 TP SILVEX NG/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 420303 | -0.5 | -100. | 13.8 | 146. | -20. | -10. | -0.03 | 32.6 | -0.01 | -0.1 | -0.1 | 51.6 |
| 420304 |  | -50. | 16.6 | 144. | -20. |  | -0.03 | 440. | -0.01 | -0.1 | 7.6 | 24.8 |
| 422101 | -1.0 | -50. | 16.1 | 139. | 99. | -10. | -0.03 | 120. | -0.01 | -0.1 | -54. | 13.0 |
| 422102 | -1.0 | -50. | 5.7 | 92. | -20. | -10. | -0.03 | 88.5 | -0.01 | -0.1 | -2.1 | 49.7 |
| 422103 | -0.5 | -100. | 10.0 | 91. | -20. | -10. | -0.03 | 23.2 | -0.01 | -0.1 | -0.1 | 32.4 |
| 422104 |  | -50. | 14.0 | 105. | 99. |  | -0.03 | 246. | -0.01 | -0.1 | 10.3 | 9.5 |
| 423701 | -1.0 | -50. | 7.4 | 52. | 99. | -10. | -0.03 | 5.4 | -0.01 | -0.1 | -54. | 70.0 |
| 423702 | -1.0 | -50. | 6.8 | 76. | -20. | -10. | -0.03 | 960. | -0.01 | -0.1 | -2.1 | 20.2 |
| 423703 | -0.5 | -100. | 6.7 | 49. | -20. | -10. | -0.03 | -0.2 | -0.01 | -0.1 | -0.1 | 18.5 |
| 423801 | -1.0 | -50. | 14.6 | 82. | 40. | -10. | -0.03 | 430. | -0.01 | -0.1 | -54. | 54.0 |
| 423803 | -0.5 | -100. | 12.0 | 87. | -20. | -10. | -0.03 | 108. | -0.01 | -0.1 | -0.1 | 25.1 |
| 423901 | 2.0 | -50. | 15.0 | 134. | 30. | -10. | -0.03 | 24. | -0.01 | -0.1 | -54. | 45.0 |
| 423903 | -0.5 | -100. | 12.6 | 89. |  | -10. | -0.03 | 6.5 | -0.01 | -0.1 | -0.1 | 17.8 |
| 423904 |  | -50. | 13.2 | 101. | -20. |  | -0.03 | 25.4 | -0.01 | -0.1 | 11.2 | 11.3 |
| 424001 | -1.0 | -50. | 16.4 | 116. | 40. | -10. | -0.03 | 5.3 | -0.01 | -0.1 | -54. | 102. |
| 424002 | -1.0 | -50. | 17.4 | 93. | -20. | -10. | -0.03 | 4.0 | -0.01 | -0.1 | -2.1 | 39.9 |
| 424003 | 0.7 | -100. | 14.2 | 90. | -20. | -10. | -0.03 | 13.6 | -0.01 | -0.1 | 0.3 | 11.6 |
| 424004 |  | -50. | 16.1 | 104. | 33. |  | -0.03 | 9.1 | -0.01 | -0.1 | 3.0 | 11.5 |
| 423601 | -1.0 | -50. | 17.6 | 71. | 116. | -10. | -0.03 | 12.0 | -0.01 | -0.1 | -54. | 17.0 |
| 423603 | -0.5 | -100. | 15.4 | 82. | 25. | -10. | -0.03 | 14.0 | -0.01 | -0.1 | -0.1 | 11.2 |
| 423604 |  | -50. | 17.4 | 89. | -20. |  | -0.03 | 14.0 | -0.01 | -0.1 | 15.5 | 4.6 |
| 410401 | -1.0 | -50. | 0.2 | 2.7 | -20. | -10. | -0.03 | 4.8 | -0.01 | -0.1 | -54. | 21.0 |
| 410403 | -0.5 | -100. | 0.6 | 4.0 | -20. | -10. | -0.03 | -0.2 | -0.01 | -0.1 | -0.1 | 35.0 |
| 410404 |  | -50. | 1.5 | 8.3 | 70. |  | -0.03 | 6.2 | -0.01 | -0.1 | -0.6 | 9.8 |
| 410503 | -0.5 | -100. | 1.7 | 53. | 72. | -10. | -0.03 | -0.2 | -0.01 | -0.1 | 5.5 | 46.6 |

(Continued)

TABLE B-1. Continued

| SAMPLE NUMBER | COLLECTION DATE | DEPTH M | TEMP DEG C | DISSOLVED OXYGEN MG/L | PH | CONDUC-TIVITY UMHOS/CM | TOTAL ALKALINITY MG/L CACO3 | DISSOLVED SOLIDS MG/L | SUSPENDED SOLIDS MG/L | TOTAL SOLIDS MG/L | VOLATILE SUSPENDED SOLIDS MG/L | BOD MG/L | COD MG/L | CL MG/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 410504 | 5/26/77 | 17.1 | 1.3 | 0.7 | 4.9 | 328. | 8. | 189. | | | | 7. | 16. | 75. |
| 410603 | 3/ 7/77 | 11.0 | 1.3 | 1.0 | 5.0 | 328. | 4. | 204. | | | | -1. | 12. | 85. |
| 410604 | 5/26/77 | 11.0 | 1.3 | 3.3 | 4.9 | 452. | 8. | 292. | | | | 4. | 16. | 111. |
| 410704 | 5/31/77 | 7.0 | 1.4 | 0.9 | 6.5 | 832. | 204. | 393. | | | | 12. | 17. | 105. |
| 422401 | 8/25/76 | 4.0 | 1.9 | 2.1 | 6.4 | 754. | 56. | | | | | 3. | | 82 |
| 422501 | 8/25/76 | 7.0 | 1.7 | 2.2 | 5.7 | 443. | 28. | | | | | 2. | | 50. |
| 422502 | 12/13/76 | 7.0 | | -0.1 | 6.0 | 638. | 92. | 233. | | | | -1. | 8 | 123. |
| 422503 | 3/ 5/77 | 7.0 | 1.7 | -0.1 | 6.9 | 708. | 135. | 328. | | | | 2. | 20. | 116. |
| 422504 | 5/29/77 | 7.0 | 1.1 | -0.1 | 6.9 | 843. | 257. | 405. | | | | 11. | 60. | 141. |
| 421501 | 8/25/76 | 4.6 | 1.9 | -0.1 | 6.4 | 566. | 98 | | | | | 3. | | 44. |
| 421502 | 12/11/76 | 4.6 | | -0.1 | 6.4 | 369. | 100. | 185. | | | | 15. | 56. | 34. |
| 421503 | 3/ 4/77 | 4.6 | 1.2 | -0.1 | 6.7 | 496. | 216. | 369. | | | | 71. | 204. | 34. |
| 421504 | 5/29/77 | 4.6 | 1.3 | 2.2 | 6.3 | 316. | 82. | 227. | | | | 10. | 63. | 34. |
| 420501 | 8/25/76 | 7.6 | 1.7 | 0.2 | 6.3 | 849. | 110. | | | | | 4. | 157. | 95. |
| 420502 | 12/11/76 | 7.6 | | -0.1 | 6.7 | 560. | 144. | 257. | | | | 10. | 56. | 46. |
| 420504 | 5/30/77 | 7.6 | 0.9 | -0.1 | 6.9 | 900. | 177. | 520. | | | | 5. | 37. | 88. |
| 421601 | 8/25/76 | 19.8 | 1.8 | -0.1 | 6.7 | 773. | 172. | | | | | -1. | | 59. |
| 421602 | 12/11/76 | 19.8 | | -0.1 | 6.8 | 1015. | 204. | 388. | | | | 4. | 80. | 178. |
| 421603 | 3/ 4/77 | 19.8 | 1.6 | -0.1 | 6.8 | 600. | 216. | 289. | | | | 2. | 39. | 69. |
| 421604 | 5/29/77 | 19.8 | 1.2 | -0.1 | 7.0 | 738. | 257. | 370. | | | | 8. | 25. | 93. |
| 423402 | 12/13/76 | | | -0.1 | 5.8 | 492. | 64. | | | | | -1. | 16. | 62. |
| 423403 | 3/ 7/77 | | 1.6 | -0.1 | 6.0 | 372. | 48. | 192. | | | | 1. | 33. | 54. |
| 423404 | 5/30/77 | | 1.6 | -0.1 | 6.0 | 363. | 84. | 209. | | | | 9. | 97. | 44. |
| 424401 | 8/24/76 | | 2.3 | 8.6 | 6.6 | 107. | 12. | 80. | 9. | 89. | 3. | 2. | | 3 |
| 424403 | 3/10/77 | | 1.4 | 7.7 | 6.9 | 110. | 20. | 88. | 9. | 97. | | 1. | 8. | 12. |

(Continued)

TABLE B-1. Continued

| SAMPLE NUMBER | SULFIDE - SULFUR MG/L-S | TOTAL COLIFORM #/100ML | FECAL COLIFORM #/100ML | TOTAL ORGANIC CARBON MG/L-C | DISSOLVED ORGANIC CARBON MG/L-C | TOTAL ORGANIC NITROGEN MG/L-N | SOLUBLE ORGANIC NITROGEN MG/L-N | NH4 MG/L-N | NO3 MG/L-N | TOTAL PHOSPHORUS MG/L-P | SOLUBLE PHOSPHORUS MG/L-P | SOLUBLE ORTHO-PHOSPHATE MG/L-P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 410504 | -0.1 | 0 | 0. | | 7.0 | | 0.7 | -0.1 | 0.6 | | 0.02 | 0.02 |
| 410603 | -0.1 | 46 | 0. | | 5.9 | | -0.1 | 0.4 | 0.2 | | 0.05 | 0.04 |
| 410604 | -0.1 | 0. | 0. | | 2.0 | | 0.6 | 0.1 | -0.1 | | 0.03 | 0.02 |
| 410704 | -0.1 | 3. | 0 | | 22.3 | | 16.7 | 22.3 | -0.1 | | 0.04 | 0.02 |
| 422401 | | 99.9 | 0. | | 5.6 | | 3.8 | 5.8 | | | 0.23 | 0.08 |
| 422501 | | 0 | 0. | | 6.4 | | 1.0 | 5.6 | | | 0.18 | 0.06 |
| 422502 | | 160. | 0. | | | | 1.3 | 5.9 | -0.1 | | 0.20 | 0.08 |
| 422503 | -0.1 | 0 | 0. | | 13.2 | | 8.4 | 8.6 | -0.1 | | 0.01 | -0.01 |
| 422504 | -0.1 | 0 | 0. | | 22.6 | | 9.4 | 14.7 | -0.1 | | 0.02 | 0.02 |
| 421501 | | 99.9 | 0. | | 23.0 | | 9.8 | 7.2 | | | 0.16 | -0.01 |
| 421502 | | 1767. | 343. | | | | | 7.1 | -0.1 | | 0.09 | 0.07 |
| 421503 | 14.5 | 99.9 | 50. | | 48.6 | | 5.1 | 13.3 | -0.1 | | 0.20 | 0.12 |
| 421504 | -0.1 | 0 | 0. | | 21.4 | | 6.7 | 4.4 | 2.4 | | 0.26 | 0.24 |
| 420501 | | 2500. | 0. | | 23.0 | | 3.4 | 7.6 | | | 0.14 | 0.08 |
| 420502 | | 99.9 | 183. | 33.6 | | | -0.1 | 12.6 | -0.1 | | -0.01 | -0.01 |
| 420504 | -0.1 | 438. | 0. | | 20.8 | | 9.9 | 16.0 | -0.1 | | 0.04 | 0.02 |
| 421601 | | 99.9 | 0. | | 6.8 | | 6.2 | 8.8 | | | 0.06 | 0.02 |
| 421602 | | 0. | 0. | | | | | 19.1 | -0.1 | | -0.01 | -0.01 |
| 421603 | -0.1 | 0. | 0. | | 7.8 | | | 9.2 | -0.1 | | 0.04 | -0.01 |
| 421604 | -0.1 | 0 | 0. | | 22.2 | | 7.4 | 11.5 | -0.1 | | 0.02 | 0.16 |
| 423402 | | 0. | 0. | 26.2 | | | | 8.1 | -0.1 | | 0.58 | 0.50 |
| 423403 | 0.1 | 7. | 0. | | 14.9 | | | 0.2 | -0.1 | | 0.33 | 0.32 |
| 423404 | -0.1 | 0. | 0. | | 17.6 | | 5.6 | 6.7 | -0.1 | | 0.26 | 0.25 |
| 424401 | | 99.9 | 400. | 1.3 | 1.2 | | | -0.1 | | 0.08 | 0.02 | 0.06 |
| 424403 | 0.1 | 99.9 | 0. | 4.4 | 3.1 | 0.5 | -0.1 | 0.3 | 4.4 | 0.05 | 0.04 | 0.03 |

(Continued)

TABLE B-1. Continued

| SAMPLE NUMBER | SO4 MG/L-SO4 | AL MG/L-AL | AS UG/L-AS | B UG/L-B | CD UG/L-CD | CA MG/L-CA | CO UG/L-CO | CR UG/L-CR | CU UG/L-CU | FE MG/L-FE | PB UG/L-PB | MG MG/L-MG | MN MG/L-MN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 410504 | 6. | -0.5 | -5. | 106 |  | 1. |  | -20 | 56. | 0.4 |  | 2.5 | 0.28 |
| 410603 | 3. | 0.6 | -10. | 78 | -20 | 1. | -50. | -20. | -50. | -0.1 | -200. | 3.4 | 0.24 |
| 410604 | 4. | -0.5 | -5 | 64. |  | 4. |  | -20. | -20. | -0.2 |  | 5.3 | 0.07 |
| 410704 | 23. | -0.5 | -5. | 514 |  |  |  | -20. | -20. |  |  | 1.4 | 3.56 |
| 422401 |  | 0.9 | -10 | 520 | -20. | 3. | -50 | -20. | -20. | 23.0 | -100. | 1.6 | 0.66 |
| 422501 |  | -0.5 | -10. | 400. | -20. | 3. | -50 | -20. | -20. | 3.6 | -100. | 1.3 | 0.09 |
| 422502 | 17 | -0.3 | -20. | 49 | -50 | 4. | -100. | -50 | -20. | 11.3 | -100. | 0.6 | 0.15 |
| 422503 | 10. | -0.3 | -10. | 383 | -20. | 1. | -50. | -20 | -50. | 26.0 | -200. | 2.6 | 0.22 |
| 422504 | 10. | -0.5 | -5. | 364. |  | 4. |  | -20. | -20. | 49.4 |  | 3.1 | 0.33 |
| 421501 |  | -0.5 | 11. | 360. | 37. | 10. | -50. | -20. | -20. | 55.0 | -100. | 4.7 | 0.84 |
| 421502 | 31 | 4.7 | -20. | 909. | -50. | 1. | -100. | -50. | 47. | 23.0 | -100. | 0.5 | 0.41 |
| 421503 | 14. | 5.5 | 25. | 576. | -20. | 1. | -50. | -20. | -50. | 13.0 | -200. | 2.1 | 0.15 |
| 421504 | 74. | 3.6 | 15. | 736. |  | 5. |  | -20. | 20. | 11.4 |  | 2.2 | 0.32 |
| 420501 |  | -0.5 | -10. | 380 | -20 | 66. | -50 | -20. | -20. | 47.0 | -100 | 3.2 | 0.46 |
| 420502 | 62. | 1.1 | -20. | 822 | -50 | 5. | -100 | -50. | -20. | 23.3 | -100. | 2.5 | 0.25 |
| 420504 | 105. | -0.5 | 16. | 716 |  | 5. |  | -20. | -20. | 21.6 |  | 2.5 | 0.08 |
| 421601 |  | -0.5 | -10. | 460 | -20. | 3. | -50. | -20. | -20. | 27.0 | -100. | 4.6 | 0.69 |
| 421602 | 5. | -0.3 | -20 | 617. | -50 | 6. | -100. | -50 | -20 | 26.0 | -100. | 3.6 | 1.27 |
| 421603 | 11. | -0.3 | -10 | 715. | -20. | 2. | -50. | -20. | -50. | 36.0 | -200. | 3.0 | 0.72 |
| 421604 | 11. | -0.5 | 8. | 407. |  | 4. |  | -20. | -20. | 38.8 |  | 5.2 | 0.68 |
| 423402 | 54. | -0.3 | -20. |  | -50. | 2. | -100. | -50. | 20. | 20.0 | -100. | 0.5 | 0.16 |
| 423403 | 58. | -0.3 | -10 | 292 | -20. |  | -50. | -20. | -50. | 13.0 | -200. | 1.2 | -0.05 |
| 423404 | 90. | -0.5 | 8 | 345 |  | 2. |  | -20. | -20. | 23.3 |  | 0.6 | 0.06 |
| 424401 |  | -0.5 | 31. | 70. | -20. | 6. | -50. | 29. | -20. | 0.6 | -100. | 4.2 | 0.07 |
| 424403 | 4. | 1.0 | 65. | 160 | -20 | 6. | -50. | -20. | -50. | 0.8 | -200. | 6.1 | 0.13 |

(Continued)

TABLE B-1. Continued

| SAMPLE NUMBER | HG UG/L-HG | NI UG/L-NI | K MG/L-K | NA MG/L-NA | ZN UG/L-ZN | SE UG/L-SE | ENDRIN NG/L | LINDANE NG/L | METHOXY-CHLOR NG/L | TOXA-PHENE NG/L | 2,4-D NG/L | 2,4,5 TP SILVEX NG/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 410504 |  | -50. | 1.5 | 64. | 48. |  | -0.03 | 5.6 | -0.01 | -0.1 | -0.6 | 14.2 |
| 410603 | -0.5 | -100. | 1.6 | 55. | 53. | -10. | -0.03 | -0.2 | -0.01 | -0.1 | -0.1 | 23.0 |
| 410604 |  | -50. | 2.4 | 93. | 58. |  | -0.03 | 3.9 | -0.01 | -0.1 | -0.6 | 2.9 |
| 410704 |  | -50. | 16.9 | 130. | 40. |  | -0.03 | 17.7 | -0.01 | -0.1 | -0.6 | 2.6 |
| 422401 | -1.0 | -50. | 12.7 | 111. | 51. | -10. | -0.03 | 34.7 | -0.01 | -0.1 | -54. | 34.6 |
| 422501 | -1.0 | -50. | 3.1 | 67. | 67. | -10. | -0.03 | 10.1 | -0.01 | -0.1 | -54. | 671. |
| 422502 | -1.0 | -50. | 6.1 | 96. | 159. | -10. | -0.03 | 18.2 | -0.01 | -0.1 | -2.1 | 45.7 |
| 422503 | -0.5 | -100. | 8.4 | 103. | 34. | -10. | -0.03 | 0.9 | -0.01 | -0.1 | 0.6 | 41.2 |
| 422504 |  | -50. | 9.8 | 127. | 25. |  | -0.03 | 108. | -0.01 | -0.1 | -0.6 | 9.4 |
| 421501 | -1.0 | -50. | 13.0 | 48. | -20. | -10. | -0.03 | 400. | -0.01 | -0.1 | -54. | -5.4 |
| 421502 | -1.0 | -50. | 6.0 | 51. | 38. | -10. | -0.03 | 280. | -0.01 | -0.1 | -2.1 | 45.4 |
| 421503 | -0.5 | -100. | 16.5 | 70. | -20. | -10. | -0.03 | 64.6 | -0.01 | -0.1 | -0.1 | 9.5 |
| 421504 |  | -50. | 11.0 | 60. | 25. |  | -0.03 | 15.0 | -0.01 | -0.1 | -0.6 | 8.8 |
| 420501 | -1.0 | -50. | 12.8 | 153. | 298. | -10. | -0.03 | 800. | -0.01 | -0.1 | -54. | 10.0 |
| 420502 | -1.0 | -50. | 11.7 | 74. | -20. | -10. | -0.03 | 320. | -0.01 | -0.1 | -2.1 | 37.8 |
| 420504 |  | -50. | 15.4 | 66. | -20. |  | -0.03 | 1040. | -0.01 | -0.1 | 15.4 | 12.9 |
| 421601 | -1.0 | -50. | 14.3 | 85. | 46. | -10. | -0.03 | 101. | -0.01 | -0.1 | -54. | 45.0 |
| 421602 | -1.0 | -50. | 15.2 | 133. | -20. | -10. | -0.03 | 4.0 | -0.01 | -0.1 | -2.1 | 35.4 |
| 421603 | -0.5 | -100. | 9.4 | 75. | -20. | -10. | -0.03 | 2.0 | -0.01 | -0.1 | -0.1 | 22.5 |
| 421604 |  | -50. | 10.0 | 130. | -20. |  | -0.03 | 18.0 | -0.01 | -0.1 | 45.6 | 71.9 |
| 423402 | -1.0 | -50. | 5.7 | 73. | 147. | -10. | -0.03 | 73.7 | -0.01 | -0.1 | -2.1 | 93.0 |
| 423403 | -0.5 | -100. | 4.7 | 59. | 92. | -10. | -0.03 | 172. | -0.01 | -0.1 | -0.1 | 7.2 |
| 423404 |  | -50. | 4.4 | 61. | 40. |  | -0.03 | 1500. | -0.01 | -0.1 | 44.1 | 12.3 |
| 424401 | -1.0 | -50. | 3.9 | 3.4 | 30. | -10. | -0.03 | 1.0 | -0.01 | -0.1 | -54. | 138. |
| 424403 | -0.5 | -100. | 2.2 | 3.0 | 111. | -10. | -0.03 | 6.4 | -0.01 | -0.1 | 0.3 | 11.1 |

(Continued)

TABLE B-1. Continued

| SAMPLE NUMBER | COLLECTION DATE | DEPTH M | TEMP DEG C | DISSOLVED OXYGEN MG/L | PH | CONDUC-TIVITY UMHOS/CM | TOTAL ALKALINITY MG/L CACO3 | DISSOLVED SOLIDS MG/L | SUSPENDED SOLIDS MG/L | TOTAL SOLIDS MG/L | VOLATILE SUSPENDED SOLIDS MG/L | BOD MG/L | COD MG/L | CL MG/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 424601 | 8/24/76 |  | 2.0 | 4.2 | 6.6 | 356 | 44. | 159. | 27. | 186. | 6 | 3. |  | 34 |
| 424603 | 3/ 9/77 |  | 1.6 | 5.2 | 7.0 | 324. | 60 | 176. | 5 | 181. |  | 4. | 12 | 51. |
| 424901 | 8/25/76 |  | 1.8 | 3.8 | 6.6 | 456 | 74. | 226. | 5 | 231. | 3 | 3. | 4 | 36 |
| 424903 | 3/10/77 |  | 1.7 | 4.5 | 6.9 | 460 | 84. | 217. | 4. | 221. |  | 2. | 26 | 34 |
| 424501 | 8/24/76 |  | 1.8 | 6.7 | 6.6 | 170. | 24 |  |  |  |  | 3. |  | 6. |
| 424503 | 3/10/77 |  | 1.6 | 12.7 | 6.3 | 102. | 8. | 129. | 21. | 150. |  | -1. | 9. | 15 |
| 424801 | 8/25/76 |  | 2.0 | 7.6 | 6.9 | 170. | 30. |  |  |  |  | 2. | 32. | 7 |
| 424803 | 3/10/77 |  | 1.4 | 10.3 | 6.7 | 157. | 16. | 127. | -1. | 125. |  | 1. | 15. | 24. |
| 424701 | 8/25/76 |  | 1.9 | 4.9 | 6.5 | 358. | 54 |  |  |  |  | 4. | 64. | 29. |
| 424703 | 3/10/77 |  | 1.5 | 7.5 | 6.7 | 313. | 48. |  |  |  |  | 1. | 18. | 45 |
| 425201 | 8/26/76 |  | 2.1 | 4.6 | 6.7 | 410. | 74. |  |  |  |  | 3. | 24. | 29. |
| 425203 | 3/10/77 |  | 1.6 | 7.6 | 7.0 | 372 | 68. | 206. | 15. | 221. |  | -1. | 13. | 65. |
| 425001 | 8/26/76 |  | 2.2 | 8.3 | 6.2 | 91. | 20. | 0. |  |  |  | -1. | 28. | 4. |
| 425003 | 3/ 9/77 |  | 1.3 | 11.0 | 6.3 | 90. | 4. | 73. | -1. | 72. |  | 1. | 25. | 9. |
| 425401 | 8/26/76 |  | 2.4 | 8.1 | 6.4 | 127. | 8. |  |  |  |  | -1. |  | 4. |
| 425403 | 3/ 9/77 |  | 1.4 | 10.8 | 6.6 | 88. | 8. | 69 | 4 | 73. |  | 1. | 14. | 9. |
| 425301 | 8/26/76 |  | 2.4 | 7.5 | 6.4 | 90 | 8. |  |  |  |  | -1. | 36. | 4 |
| 425303 | 3/ 9/77 |  | 1.4 | 11.1 | 6.4 | 86. | 4. | 67. | 4. | 71. |  | 1. | 17. | 26 |
| 425101 | 8/26/76 |  | 2.4 | 8.0 | 6.4 | 107. | 8. |  |  |  |  | -1. | 20. | 6. |
| 425103 | 3/10/77 |  | 1.4 | 9.9 | 6.8 | 100. | 12. | 79. | 5 | 84. |  | 1. | 8. | 12. |

(Continued)

TABLE B-1. Continued

| SAMPLE NUMBER | SULFIDE-SULFUR MG/L-S | TOTAL COLIFORM #/100ML | FECAL COLIFORM #/100ML | TOTAL ORGANIC CARBON MG/L C | DISSOLVED ORGANIC CARBON MG/L-C | TOTAL ORGANIC NITROGEN MG/L-N | SOLUBLE ORGANIC NITROGEN MG/L-N | NH4 MG/L-N | NO3 MG/L-N | TOTAL PHOSPHORUS MG/L-P | SOLUBLE PHOSPHORUS MG/L-P | SOLUBLE ORTHO-PHOSPHATE MG/L-P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 424601 |  | 99.9 | 0 |  | 2.3 |  |  | -0.1 |  | 0.06 | -0.01 | 0.06 |
| 424603 | -0.1 | 99.9 | 0. | 9.9 | 7.7 | -0.1 | -0.1 | 0.6 | 3.4 | 0.03 | 0.03 | 0.01 |
| 424901 |  | 4900 | 0 | 3.7 | 2.7 |  |  | 7.0 |  | 0.11 | 0.02 | 0.06 |
| 424903 | -0.1 | 99.9 | 0. | 8.2 | 6.4 | 5.3 | -0.1 | 6.0 | 3.6 | 0.13 | 0.09 | 0.09 |
| 424501 |  | 99.9 | 2000. | 2.3 | 1.4 |  |  | 3.9 |  | 0.16 | 0.10 | 0.06 |
| 424503 | -0.1 | 250. | 0. | 3.2 | 2.2 | 0.2 | -0.1 | 1.0 | 8.4 | 0.04 | 0.04 | 0.02 |
| 424801 |  | 99.9 | 0 |  | 1.5 |  |  | 3.0 |  | 0.10 | 0.02 | 0.06 |
| 424803 | -0.1 | 99.9 | 0 | 3.6 | 3.7 | 1.1 | -0.1 | 0.5 | 5.9 | 0.04 | 0.04 | 0.03 |
| 424701 |  | 99.9 | 0 |  | 2.0 | 0.6 |  | 6.0 |  | 0.06 | -0.01 | 0.06 |
| 424703 | -0.1 | 115. | 0 | 8.3 | 5.7 | 0.4 | -0.1 | 3.5 | 3.6 | 0.05 | 0.04 | 0.04 |
| 425201 |  | 99.9 | 100. | 4.8 |  |  |  | 2.1 |  | 0.19 | 0.10 | 0.06 |
| 425203 | -0.1 | 99.9 | 1 | 10.0 | 5.8 | 20.9 | -0.1 | 4.9 |  | 0.09 | 0.03 | 0.07 |
| 425001 |  | 8700. | 0 | 6.0 | 4.5 |  |  | 2.8 |  | 0.17 | 0.12 | -0.01 |
| 425003 | -0.1 | 99.9 | 0 | 0.6 | 6.2 | 0.8 | 0.6 | 0.4 | 1.6 | 0.09 | 0.06 | 0.06 |
| 425401 |  | 0. | 0 | 5.5 |  |  |  | 0.7 |  | 0.21 | 0.08 | 0.08 |
| 425403 | -0.1 | 99.9 | 3. | 6.4 | 6.5 | 0.8 | 0.4 | 0.1 | 1.8 | 0.08 | 0.05 | 0.03 |
| 425301 |  | 0 | 0 | 6.7 | 4.5 |  |  | 0.8 |  | 0.15 | 0.08 | 0.06 |
| 425303 | -0.1 | 99.9 | 35 | 7.8 | 5.4 | 0.5 | -0.1 | 0.1 | 1.6 | 0.08 | 0.06 | 0.04 |
| 425101 |  | 7700. | 0 | 6.0 | 4.3 |  |  | 1.3 |  | 0.21 | 0.10 | -0.01 |
| 425103 | -0.1 | 99.9 | 0 | 5.6 | 6.4 | 0.9 | 0.2 | 0.4 | 1.8 | 0.07 | 0.05 | 0.03 |

(Continued)

TABLE B-1. Continued

| SAMPLE NUMBER | SO4 MG/L-SO4 | AL MG/L-AL | AS UG/L-AS | B UG/L-B | CD UG/L-CD | CA MG/L-CA | CO UG/L-CO | CR UG/L-CR | CU UG/L-CU | FE MG/L-FE | PB UG/L-PB | MG MG/L-MG | MN MG/L-MN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 424601 | | -0.5 | -10 | 200 | -20 | 2 | -50 | 63 | -20. | 8.5 | -100. | 3.2 | 0.15 |
| 424603 | 10. | -0.3 | 30 | 204 | -20 | 4. | -50 | -20 | -50. | 7.4 | -200. | 4.1 | 0.15 |
| 424901 | | -0.5 | -10 | 280 | -20 | 5 | -50 | -20 | -20. | 7.7 | -100. | 3.1 | 0.11 |
| 424903 | 14. | -0.3 | 20 | 371 | -20. | 4 | -50 | -20 | -50 | 6.6 | -200 | 3.8 | 0.15 |
| 424501 | | -0.5 | -10 | 90 | -20. | 10 | -50 | -20 | -20. | 0.3 | -100. | 4.9 | -0.05 |
| 424503 | 8 | 0.3 | -10. | 37 | -20 | 10 | -50. | -20 | -50. | 0.1 | -200. | 6.6 | -0.05 |
| 424801 | | -0.5 | -10 | 60 | -20 | 11 | -50 | -20 | -20. | 0.4 | -100. | 4.6 | -0.05 |
| 424803 | 8. | 0.5 | 14 | | -20 | 11. | -50. | -20. | -50. | -0.1 | -200. | 6.8 | 0.15 |
| 424701 | | -0.5 | -10. | 160 | -20 | 3. | -50. | 38. | -20. | 5.3 | -100. | 3.5 | 0.08 |
| 424703 | 8. | -0.3 | -10 | 256 | -20. | 7. | -50 | -20 | -50. | 4.3 | -200. | 5.3 | 0.08 |
| 425201 | | -0.5 | -10 | 240. | -20. | 4. | -50. | -20 | -20. | 6.9 | -100. | 3.6 | 0.11 |
| 425203 | 14. | -0.3 | -10. | 249 | -20 | 5. | -50 | -20 | -50. | 8.6 | -200 | 5.8 | 0.13 |
| 425001 | | -0.5 | 83. | 120 | -20. | 3. | -50. | -20 | -20. | 0.8 | -100. | 2.1 | -0.05 |
| 425003 | 16 | -0.3 | 142 | 121. | -20. | 2. | -50. | -20 | -50. | 0.2 | -200. | 3.6 | -0.05 |
| 425401 | | -0.5 | 402. | 110 | -20. | 4. | -50. | -20 | -20. | 0.9 | -100. | 2.1 | -0.05 |
| 425403 | 16 | -0.3 | 145. | 446. | -20. | 3. | -50. | 57. | -50. | 0.3 | -200. | 3.2 | 0.06 |
| 425301 | | -0.5 | 360. | 90 | -20. | 3 | -50. | -20. | -20. | 0.9 | -100. | 2.2 | -0.05 |
| 425303 | 15 | -0.3 | 126 | 271 | -20 | 4. | -50. | -20. | -50. | 1.3 | -200. | 3.0 | 0.06 |
| 425101 | | -0.5 | 219. | 100 | -20. | 3. | -50. | -20. | -20. | 1.0 | -100. | 2.4 | -0.05 |
| 425103 | 16 | 0.5 | 104 | 136. | -20 | 3. | -50 | -20. | -50. | 0.6 | -200. | 3.4 | 0.06 |

(Continued)

TABLE B-1. Continued

| SAMPLE NUMBER | HG UG/L-HG | NI UG/L-NI | K MG/L-K | NA MG/L-NA | ZN UG/L-ZN | SE UG/L-SE | ENDRIN NG/L | LINDANE NG/L | METHOXY-CHLOR NG/L | TOXA-PHENE NG/L | 2,4-D NG/L | 2,4,5 TP SILVEX NG/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 424601 | -1.0 | -50. | 5.7 | 41.0 | -20. | -10. | -0.03 | 3.50 | -0.01 | -0.1 | -54. | 66.1 |
| 424603 | -0.5 | -100. | 4.3 | 43.0 | -20. | -10. | -0.03 | 2.50 | -0.01 | -0.1 | 0.30 | 22.5 |
| 424901 | -1.0 | -50. | 7.6 | 59.0 | -20. | -10. | -0.03 | 82.60 | -0.01 | -0.1 | -54. | 70.1 |
| 424903 | -0.5 | -100. | 5.9 | 58.0 | -20. | -10. | -0.03 | 22.20 | -0.01 | -0.1 | -0.10 | 6.2 |
| 424501 | -1.0 | -50. | 7.3 | 5.0 | -20. | -10. | -0.03 | 68.00 | -0.01 | -0.1 | -54. | 89.2 |
| 424503 | -0.5 | -100. | 3.6 | 6.2 | -20. | -10. | -0.03 | 316.00 | -0.01 | -0.1 | | |
| 424801 | -1.0 | -50. | 7.6 | 5.0 | -20. | -10. | -0.03 | 8.00 | -0.01 | -0.1 | -54. | 117. |
| 424803 | -0.5 | -100. | 3.3 | 3.8 | -20. | -10. | -0.03 | -0.20 | -0.01 | -0.1 | -0.10 | 6.4 |
| 424701 | -1.0 | -50. | 7.0 | 38.0 | -20. | -10. | -0.03 | 31.20 | -0.01 | -0.1 | -54. | 79.4 |
| 424703 | -0.5 | -100. | 4.5 | 36.0 | 34. | -10. | -0.03 | 3.10 | -0.01 | -0.1 | 0.40 | 9.9 |
| 425201 | -1.0 | -50. | 8.4 | 49.0 | -20. | -10. | -0.03 | 241.00 | -0.01 | -0.1 | -54. | 57.4 |
| 425203 | -0.5 | -100. | 6.0 | 51.0 | -20. | -10. | -0.03 | 0.90 | -0.01 | -0.1 | 12.90 | 43.4 |
| 425001 | -1.0 | -50. | 2.0 | 2.5 | -20. | -10. | -0.03 | 28.40 | -0.01 | -0.1 | -54. | 142. |
| 425003 | -0.5 | -100. | 1.6 | 5.0 | -20. | -10. | -0.03 | -0.20 | -0.01 | -0.1 | 0.40 | 24.5 |
| 425401 | -1.0 | -50. | 2.0 | 2.1 | -20. | -10. | -0.03 | 42.50 | -0.01 | -0.1 | -54. | 94.5 |
| 425403 | -0.5 | -100. | 1.5 | 5.1 | -20. | -10. | -0.03 | -0.20 | -0.01 | -0.1 | -0.10 | 5.0 |
| 425301 | -1.0 | 57. | 2.2 | 3.5 | -20. | -10. | -0.03 | 138.00 | -0.01 | -0.1 | -54. | 93.7 |
| 425303 | -0.5 | -100. | 1.6 | 5.0 | 25. | -10. | -0.03 | -0.20 | -0.01 | -0.1 | 1.60 | 33.7 |
| 425101 | -1.0 | -50. | 2.7 | 4.4 | -20. | -10. | -0.03 | 56.00 | -0.01 | -0.1 | -54. | 74.9 |
| 425103 | -0.5 | -100. | 1.9 | 6.2 | -20. | -10. | -0.03 | -0.20 | -0.01 | -0.1 | 0.80 | 58.9 |

TABLE B-2. SOIL DATA

| SAMPLE NUMBER | COLLECTION DATE | DEPTH M | PH | INORGANIC NITROGEN UG/GM-N | TOTAL ORGANIC NITROGEN UG/GM-N | TOTAL PHOSPHORUS UG/GM-P | AVAILABLE PHOSPHORUS UG/GM-P | TOTAL SULFUR UG/GM-S |
|---|---|---|---|---|---|---|---|---|
| 41111 | 8/26/76 | 0.00 | 3.9 | 19.3 | 31. | 16. | 1.0 | 114. |
| 41131 | 3/10/77 | 0.00 | 3.5 | 11.2 | 130. | 16. | 1.2 | 33. |
| 41115 | 8/26/76 | 1.00 | 4.4 | 38.2 | 6. | 26. | 3.0 | 133. |
| 41135 | 3/10/77 | 1.00 | 3.9 | 7.1 | 36. | 39. | 2.4 | 37. |
| 41116 | 8/26/76 | 3.00 | 5.1 | 9.1 | -1. | 14. | 3.0 | 144. |
| 41136 | 3/10/77 | 3.00 | 4.1 | 6.4 | 6. | 18. | 4.6 | 110. |
| 41211 | 8/26/76 | 0.00 | 4.2 | 31.1 | 210. | 24. | 1.0 | 110. |
| 41215 | 8/26/76 | 1.00 | 4.5 | 31.5 | 18. | 28. | 3.0 | 110. |
| 41216 | 8/26/76 | 3.00 | 6.1 | 13.0 | -1. | 18. | 3.0 | 94. |
| 41311 | 8/26/76 | 0.00 | 4.4 | 15.9 | 262. | 44. | 4.0 | 208. |
| 41315 | 8/26/76 | 1.00 | 4.7 | 14.7 | 9. | 30. | 2.0 | 84. |
| 41316 | 8/26/76 | 3.00 | 5.5 | 6.8 | 1. | 19. | 10.0 | 64. |
| 42111 | 8/26/76 | 0.00 | 4.4 | 24.4 | 428. | 92. | 37.0 | 150. |
| 42131 | 3/10/77 | 0.00 | 5.7 | 19.6 | 579. | 178. | 17.0 | 408. |
| 42115 | 8/26/76 | 1.00 | 5.1 | 18.1 | 50. | 78. | 57.0 | 78. |
| 42135 | 3/10/77 | 1.00 | 4.4 | 14.6 | 45. | 135. | 55.0 | 43. |
| 42116 | 8/26/76 | 3.00 | 6.6 | 8.4 | 16. | 130. | 85.0 | 100. |
| 42136 | 3/10/77 | 3.00 | 4.9 | 14.6 | 27. | 107. | 29.0 | 55. |
| 42211 | 8/26/76 | 0.00 | 5.0 | 41.4 | 576. | 326. | 209. | 224. |
| 42231 | 3/10/77 | 0.00 | 5.8 | 14.8 | 425. | 313. | 46.0 | 232. |
| 42215 | 8/26/76 | 1.00 | 5.3 | 55.1 | 39. | 144. | 142. | 62. |
| 42235 | 3/10/77 | 1.00 | 5.8 | 12.5 | 65. | 187. | 58.0 | 77. |
| 42216 | 8/26/76 | 3.00 | 5.6 | 10.2 | 27. | 119. | 71.0 | 77. |
| 42236 | 3/10/77 | 3.00 | 5.7 | 7.7 | 41. | 99. | 29.0 | 77. |
| 42311 | 8/26/76 | 0.00 | 4.7 | 19.2 | 534. | 341. | 157. | 213. |
| 42331 | 3/10/77 | 0.00 | 5.8 | 17.5 | 452. | 191. | 47.0 | 289. |
| 42315 | 8/26/76 | 1.00 | 5.2 | 10.0 | 21. | 115. | 56.0 | 85. |
| 42335 | 3/10/77 | 1.00 | 5.7 | 32.1 | 39. | 97. | 34.0 | 58. |
| 42316 | 8/26/76 | 3.00 | 5.8 |  |  | 96. | 30.0 | 53. |
| 42336 | 3/10/77 | 3.00 | 4.8 | 21.0 | 19. | 41. | 14.0 | 20. |
| 42426 | 8/22/76 | 3.35 | 5.4 | 12.1 | 2. | 42. | 23.0 | 66. |
| 42428 | 8/22/76 | 3.35 | 6.2 | 10.2 |  | 39. | 17.0 | 64. |
| 42429 | 8/22/76 | 7.92 | 6.1 | 12.2 | 1. | 46. | 6.0 | 82. |

(Continued)

TABLE B-2. Continued

| SAMPLE NUMBER | CATION EX-CAP MEQ/100G | EXTR. AL UG/GM | EXTR. B UG/GM | EXTR. CD UG/GM | EXCH. CA MG/GM | EXTR. CO UG/GM | EXTR. CR UG/GM | EXTR CU UG/GM | EXTR. FE UG/GM | EXTR. PB UG/GM | EXCH MG MG/GM | EXTR. MN UG/GM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 41111 | 0.57 | 78. | 0.82 | -0.05 | 0.028 | -0.12 | -0.05 | -0.05 | 60. | -0.5 | -0.01 | 2.23 |
| 41131 | 0.71 | 23. | 1.01 | -0.05 | 0.007 | -0.12 | -0.12 | 0.90 | 25. |  | -0.01 | 0.50 |
| 41115 | 0.40 | 64. | 0.03 | -0.05 | 0.019 | -0.12 | -0.05 | 0.14 | 20. | -0.5 | -0.01 | 0.36 |
| 41135 | 0.23 |  | 0.13 | -0.05 | 0.007 | -0.12 | -0.12 | 0.80 |  |  | -0.01 | 9.40 |
| 41116 | 0.64 | 41. | 0.16 | -0.05 | 0.031 | -0.12 | -0.05 | 0.51 | 12. | 0.6 | -0.01 | 0.71 |
| 41136 | 0.10 | 40. | 0.39 | -0.05 | 0.003 | -0.12 | -0.12 | 0.50 | 83. |  | -0.01 | 2.20 |
| 41211 | 0.82 | 36. | 0.09 | -0.05 | 0.001 | -0.12 | -0.05 | -0.05 | 64. | 1.9 | -0.01 | 0.94 |
| 42131 | 0.57 | 52. | 0.10 | -0.05 | 0.099 | -0.12 | -0.12 | 17.00 | 51. |  | -0.01 | 0.45 |
| 41215 | 0.46 | 64. | 0.01 | -0.05 | 0.021 | -0.12 | -0.05 | -0.05 | 7. | -0.5 | -0.01 | 2.43 |
| 42135 | 0.18 | 86. | 0.19 | -0.05 | 0.011 | -0.12 | -0.12 | 11.00 | 23. |  | -0.01 | 0.15 |
| 41216 | 0.50 | 54. | 0.12 | -0.05 | 0.036 | -0.12 | -0.05 | -0.05 | 3. | -0.5 | 0.01 | 1.07 |
| 42136 | 0.17 | 27. | 0.57 | -0.05 | 0.019 | -0.12 | -0.12 | 11.00 | 70. |  | -0.01 | 0.24 |
| 41311 | 1.57 |  | 0.13 | -0.05 | 0.022 | -0.12 | -0.05 | -0.05 | 60. | -0.5 | -0.01 | 3.58 |
| 41315 | 0.84 | 56. | 0.12 | -0.05 | 0.036 | -0.12 | -0.05 | 0.16 | 72. | -0.5 | 0.01 | 0.59 |
| 41316 | 0.21 | 42. | 0.07 | -0.05 | 0.018 | -0.12 | -0.05 | -0.05 | 16. | -0.5 | -0.01 | 0.51 |
| 42111 | 0.82 | 26. | 0.13 | 0.09 | 0.054 | -0.12 | -0.05 | 7.10 | 45. | 8.1 | -0.01 | 0.71 |
| 42115 | 0.24 | 38. | 0.22 | -0.05 | 0.035 | -0.12 | -0.05 | 0.67 | 10. | 0.5 | -0.01 | 0.42 |
| 42116 | 0.64 | 63. | 0.24 | -0.05 | 0.053 | -0.12 | -0.05 | 0.70 | 10. | 0.8 | -0.01 | 0.62 |
| 42211 | 1.11 | 63. | 0.29 | -0.05 |  | -0.12 | 0.05 | 12.00 | 25. | 4.3 | 0.01 | 0.59 |
| 42231 | 0.56 | 51. | 0.62 | -0.05 | 0.092 | -0.12 | -0.12 | 14.00 | 29. |  | 0.01 | 0.65 |
| 42215 | 0.41 | 34. | 0.09 | -0.05 | 0.033 | -0.12 | -0.05 | 2.20 | 3. | -0.5 | 0.01 | -0.12 |
| 42235 | 0.38 | 74. | 0.45 | -0.05 | 0.025 | -0.12 | -0.12 | 16.00 | 25. |  | -0.01 | 0.28 |
| 42216 | 0.75 | 13. | 0.13 | -0.05 | 0.038 | -0.12 | -0.05 | 0.87 | 8. | -0.5 | -0.01 | 0.22 |
| 42236 | 0.15 | 32. | 0.19 | -0.05 | 0.018 | -0.12 | -0.12 | 16.00 | 22. |  | -0.01 | 0.26 |
| 42311 | 1.14 | 23. | 0.43 | -0.05 | 0.070 | -0.12 | 0.05 | 3.80 | 39. | 3.0 | 0.01 | 0.65 |
| 42331 | 0.52 | 36. | 0.06 | -0.05 | 0.083 | -0.12 | -0.12 | 5.40 | 27. |  | 0.01 | 0.74 |
| 42315 | 0.37 | 53. | 0.17 | -0.05 | 0.060 | -0.12 | -0.05 | 0.26 | 45. | -0.5 | 0.01 | 0.71 |
| 42335 | 0.16 | 234. | 0.01 | -0.05 | 0.027 | -0.12 | -0.12 | 4.50 | 40. |  | -0.01 | 0.41 |
| 42316 | 0.61 | 65. | 0.13 | 0.05 | 0.032 | -0.12 | -0.05 | -0.05 | 100. | -0.5 | -0.01 | 1.08 |
| 42336 | 0.10 | 32. | 0.60 | -0.05 | 0.016 | -0.12 | -0.12 | 1.40 | 25. |  | -0.01 |  |
| 42426 | 0.43 | 19. | 0.20 | -0.05 | 0.034 | -0.12 | -0.05 | -0.05 | 15. | -0.5 | 0.01 | 0.48 |
| 42428 | 0.57 |  | 0.12 | -0.05 | 0.047 | -0.12 | 0.06 | -0.05 | 27. | -0.5 | -0.01 | 1.38 |
| 42429 | 0.50 | 60. |  | 0.16 | 0.039 | -0.12 | 0.05 | -0.05 | 107. | -0.5 | -0.01 | 2.26 |

(Continued)

TABLE B-2. Continued

| SAMPLE NUMBER | EXTR. NI UG/GM | EXCH. K MG/GM | EXCH. NA MG/GM | EXTR ZN UG/GM | ENDRIN NG/GM | LINDANE NG/GM | METHOXYCHLOR NG/GM | TOXAPHENE NG/GM | 2,4-D NG/GM | SILVEX NG/GM | TOTAL AL MG/GM | TOTAL CD UG/GM | TOTAL CA MG/GM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 41111 | -0.2 | -0.01 | -0.01 | 1.5 | -0.60 | 0.54 | -0.01 | -0.60 | -0.13 | 0.84 | 0.9 | -2. | 0.07 |
| 41131 | -0.1 | -0.01 | -0.01 | -2.5 | -0.11 | -0.11 | -0.53 | -0.53 | -0.02 | 1.34 | 0.6 | -2. | 0.05 |
| 41115 | -0.2 | -0.01 | -0.01 | -0.5 |  |  |  |  |  |  | 1.6 | -2 | 0.02 |
| 41135 | -0.1 | -0.01 | -0.01 | -2.5 |  |  |  |  |  |  | 2.2 | -2. | 0.06 |
| 41116 | -0.2 | 0.01 | -0.01 | -0.5 |  |  |  |  |  |  | 0.7 | -2. | 0.04 |
| 41136 | -0.1 | -0.01 | -0.01 | -2.5 |  |  |  |  |  |  | 1.3 | -2. | 0.04 |
| 41211 | -0.2 | -0.01 | -0.01 | -0.5 | -0.60 | 2.11 | -0.01 | -0.60 | -0.13 | 1.27 | 0.5 | -2. | 0.05 |
| 41215 | -0.2 | 0.01 | 0.01 | -0.5 |  |  |  |  |  |  | 1.6 | -2. | 0.04 |
| 41216 | -0.2 | -0.01 | -0.01 | -0.5 |  |  |  |  |  |  | 1.4 | -2. | 0.21 |
| 41311 | -0.2 | -0.01 | -0.01 | -0.5 | -0.60 | 1.47 | -0.01 | -0.60 | -0.13 | 1.57 | 1.2 | -2. | 0.03 |
| 41315 | -0.2 | 0.01 | 0.01 | 3.0 |  |  |  |  |  |  | 1.2 | -2. | 0.03 |
| 41316 | -0.2 | -0.01 | 0.01 | -0.5 |  |  |  |  |  |  | 0.6 | -2. | 0.02 |
| 42111 | -0.2 | -0.01 | -0.01 | 12.0 | -0.60 | 24.19 | -0.01 | -0.60 | -0.13 | 4.12 | 0.9 | -2. | 0.11 |
| 42131 | 0.4 | -0.01 | -0.01 | 8.5 | -0.11 | 1.55 | -0.53 | -0.53 | -0.02 | 5.18 | 1.4 | -2. | 0.13 |
| 42115 | -0.2 | 0.01 | 0.01 | 2.5 |  |  |  |  |  |  | 1.3 | -2. | 0.07 |
| 42135 | -0.1 | -0.01 | -0.01 | -2.5 |  |  |  |  |  |  | 1.7 | -2. | 0.08 |
| 42116 | -0.2 | 0.01 | 0.01 | 2.7 |  |  |  |  |  |  | 0.8 | -2. | 0.07 |
| 42136 | 0.3 | -0.01 | -0.01 | 9.4 |  |  |  |  |  |  | 1.6 | -2. | 0.06 |
| 42211 | -0.2 | 0.01 | 0.01 | 2.6 | -0.60 | 26.59 | -0.01 | -0.60 | -0.13 | 1.61 | 1.8 | -2. | 0.20 |
| 42231 | 0.1 | 0.03 | 0.02 | 8.9 | -0.11 | 37.52 | -0.53 | -0.53 | -0.02 | 1.89 | 2.0 | -2. | 0.14 |
| 42215 | -0.2 | 0.01 | 0.01 | 3.0 |  |  |  |  |  |  | 1.1 | -2. | 0.06 |
| 42235 | 0.1 | -0.01 | 0.02 | 9.3 |  |  |  |  |  |  | 1.6 | -2. | 0.09 |
| 42216 | -0.2 | 0.01 | 0.02 | 11.0 |  |  |  |  |  |  | 0.9 | -2. | 0.08 |
| 42236 | 0.1 | -0.01 | 0.02 | -2.5 |  |  |  |  |  |  | 1.6 | -2. | 0.04 |
| 42311 | -0.2 | 0.02 | 0.01 | 8.4 | -0.60 | 75.79 | -0.01 | -0.60 | -0.13 | 2.83 | 2.2 | -2. | 0.13 |
| 42331 | -0.1 | 0.02 | 0.01 | 9.1 | -0.11 | 37.68 | -0.53 | -0.53 | -0.02 | 4.24 | 2.5 | -2. | 0.19 |
| 42315 | -0.2 |  | 0.01 | -0.5 |  |  |  |  |  |  | 1.8 | -2. | 0.08 |
| 42335 | 0.2 | -0.01 | 0.01 | 5.7 |  |  |  |  |  |  | 2.3 | -2. | 0.06 |
| 42316 | -0.2 |  | 0.01 | -0.5 |  |  |  |  |  |  | 1.8 | -2. | 0.13 |
| 42336 | -0.1 | -0.01 | 0.01 | -2.5 |  |  |  |  |  |  | 2.0 | -2. | 0.06 |
| 42426 | -0.2 | 0.01 | 0.01 | 1.5 |  |  |  |  |  |  | 0.8 | -2 | 0.07 |
| 42428 | -0.2 | -0.01 | 0.01 | -0.5 | -0.60 | 70.03 | -0.01 | -0.60 | -0.13 | 2.74 | 0.7 | -2 | 0.04 |
| 42429 | -0.2 | -0.01 | 0.01 | 4.0 |  |  |  |  |  |  | 0.7 | -2. | 0.05 |

(Continued)

TABLE B-2. Continued

| SAMPLE NUMBER | TOTAL CO UG/GM | TOTAL CR UG/GM | TOTAL CU UG/GM | TOTAL FE MG/GM | TOTAL PB UG/GM | TOTAL MG MG/GM | TOTAL MN UG/GM | TOTAL HG UG/GM | TOTAL NI UG/GM | TOTAL K MG/GM | TOTAL NA MG/GM | TOTAL ZN UG/GM | TOTAL AS UG/GM | TOTAL SE UG/GM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 41111 | -2. | -5. | 2. | 2.1 | -10. | -0.01 | 46. | -1.0 | -10. | -0.2 | -0.05 | 3. | -2. | -1. |
| 41131 | -2. | -2. | -5. | 1.3 |  | 0.02 | 39. | -0.2 | -20. | 0.2 | 0.12 | 1. | -1. | 1. |
| 41115 | -2. | -5. | 2. | 2.8 | -10 | -0.01 | 55. | -1.0 | -10. | 0.6 | 0.08 | 5. | 2 | -1. |
| 41135 | -2. | -2. | -5. | 3.5 |  | 0.07 | 59. | -0.2 | -20. | 0.4 | 0.15 | 12. | -1 | -1. |
| 41116 | -2. | -5. | 2. | 1.0 | -10. | 0.01 | 12. | -1.0 | -10. | -0.2 | -0.05 | -2. | -2 | -1. |
| 41136 | -2. | -2 | -5. | 1.3 |  | 0.03 | 26. | -0.2 | -20. | 0.3 | 0.11 | 5. | 2. | -1. |
| 41211 | -2. | -5. | -2. | 1.7 | -10. | 0.02 | 41. | -1.0 | -10. | -0.2 | -0.05 | -2. | -2. | -1. |
| 41215 | -2. | -5. | 2. | 2.6 | -10. | -0.01 | 63. | -1.0 | -10. | 0.2 | 0.06 | 4. |  |  |
| 41216 | -2. | 6. | 2. | 2.7 | -10. | 0.01 | 82. | -1.0 | -10. | 0.8 | 0.25 | 4. | -2 | -1. |
| 41311 | -2. | -5. | 2. | 2.6 | -10. | 0.01 | 46. | -1.0 | -10. | 0.3 | 0.09 | 4 | 3 | -1. |
| 41315 | -2. | -5. | 2. | 2.6 | -10. | -0.01 | 51. | -1.0 | -10. | 0.4 | 0.10 | 4. | 2. | -1. |
| 41316 | -2. | -5. | 2. | 1.6 | -10. | -0.01 | 45. | -1.0 | -10. | 0.4 | 0.13 | -2. | -2. | -1. |
| 42111 | -2. | 6. | 16. | 1.7 | 28. | 0.08 | 38. | -1.0 | -10. | -0.2 | 0.10 | 22. |  |  |
| 42131 | -2. | 4. | 10. | 1.3 |  | 0.21 | 26. | -0.2 | -20. | 0.3 | 0.16 | 21. | 1. | -1. |
| 42115 | -2. | -5. | 4. | 2.4 | -10. | 0.05 | 67. | -1.0 | -10 | 0.3 | 0.11 | 9. | -2. | -1. |
| 42135 | -2. | -2. | -5. | 1.9 |  | 0.06 | 43. | -0.2 | -20. | 0.4 | 0.16 | 8 | -1 | 1. |
| 42116 | -2. | -5. | 3. | 1.4 | -10. | 0.03 | 26. | -1.0 | -10. | -0.2 | 0.06 | 6. | 2. | -1. |
| 42136 | -2. | -2. | -5. | 1.7 |  | 0.06 | 37. | -0.2 | -20. | 0.4 | 0.14 | 15. | 1. | -1. |
| 42211 | -2. | 9. | 21. | 2.2 | 16. | 0.08 | 42. | -1.0 | -10. | 0.2 | 0.24 | 19. | -2 | -1. |
| 42231 | -2. | -2. | 10. | 1.7 |  | 0.09 | 47. | -0.2 | -20. | 0.3 | 0.16 | 24. | 1 | 1. |
| 42215 | -2. | 5. | 7. | 2.2 | -10. | 0.04 | 50. | -1.0 | -10. | 0.2 | 0.08 | 9. | 2. | -1. |
| 42235 | -2. | -2. | 5. | 1.2 |  | 0.03 | 26. | -0.2 | -20. | 0.3 | 0.17 | 17. | -1. | -1. |
| 42216 | -2. | -5. | 4. | 2.2 | -10. | 0.05 | 50. | -1.0 | -10. | 0.3 | 0.11 | 20. | -2. | -1. |
| 42236 | -2. | -2. | -5. | 1.4 |  | 0.07 | 22. | -0.2 | -20. | 0.4 | 0.18 | 8. | 2. | -1. |
| 42311 | -2. | 5. | 10. | 2.3 | -10. | 0.06 | 43. | -1.0 | -10. | 0.2 | 0.12 | 29. |  |  |
| 42331 | -2. | 4. | 10. | 2.3 |  | 0.07 | 37. | -0.2 | -20 | 0.4 | 0.18 | 18. | 1 | 1. |
| 42315 | -2. | 5. | 3. | 2.7 | -10. | 0.07 | 73. | -1.0 | -10. | 0.4 | 0.12 | 18 | 3 | -1. |
| 42335 | -2. | -2. | -5. | 2.8 |  | 0.03 | 48. | -0.2 | -20. | 0.6 | 0.28 | 14 | 2. | -1. |
| 42316 | -2. | 6. | 3. | 3.2 | -10. | 0.05 |  | -1.0 | -10. | 0.4 | 0.31 | 13. | 2 | -1. |
| 42336 | -2. | -2. | -5. | 1.9 |  | 0.06 | 44. | -0.2 | -20 | 0.6 | 0.34 | 8 | 1. | 1. |
| 42426 | -2. | -5. | 2. | 1.7 | -10. | 0.04 | 27. | -1.0 | -10. | 0.2 | 0.10 | 3. | -2. | -1. |
| 42428 | -2. | -5. | 2. | 1.7 | -10. | 0.03 | 22. | -1.0 | -10. | -0.2 | -0.05 | 3. | 2. | -1. |
| 42429 | -2. | 10. | 3. | 3.0 | -10. | 0.02 | 92. | -1.0 | -10. | -0.2 | -0.05 | 11. | -2. | -1. |

# GLOSSARY

Adsorption: A process in which soluble substances are attracted to and held at the surface of soil particles.

Advanced wastewater treatment: Additional treatment designed to reduce concentrations of selected constituents present in wastewater after secondary treatment.

Alkali soil: A soil with a high degree of alkalinity (pH of 8.5 or higher) or with a high exchangeable sodium content (15 percent or more of the exchange capacity) or both.

Aquiclude: A geologic formation which is porous and capable of absorbing water but will not transmit it rapidly enough to supply a well or spring.

Aquifer: A geologic formation or strata that contains water and transmits it from one point to another in quantities sufficient to permit economic development.

Consumptive use: Synonymous with evapotranspiration.

Conventional wastewater treatment: Reduction of pollutant concentrations in wastewater by physical, chemical, or biological means.

Drainability: Ability of the soil system to accept and transmit water by infiltration and percolation.

Effective precipitation: Precipitation that enters the soil and is useful for plant growth.

Evapotranspiration: The unit amount of water lost from a given area by transpiration, building of plant tissue, and evaporation from the soil surface, snow, or intercepted precipitation in a specified period of time.

Fixation: A combination of physical and chemical mechanisms in the soil that act to retain wastewater constituents within the soil, including adsorption, chemical precipitation, and ion exchange.

Groundwater: The body of water that is retained in the saturated zone that tends to move by hydraulic gradient to lower levels.

Groundwater table: The free surface elevation of the groundwater; this level will rise and fall with additions or withdrawals.

Infiltration: The entrance of applied water into the soil through the soil-water interface.

Infiltration-percolation: An approach to land application in which large volumes of wastewater are applied to the land, infiltrate the surface, and percolate through the soil pores.

Irrigation: Application of water to the land to meet the growth needs of plants.

Land application: The discharge of wastewater onto the soil for treatment or reuse.

Loading rates: The average amount of liquid or solids applied to the land over a fixed time period, taking into account periodic resting.

Lysimeter: A device for measuring percolation and leaching losses from a column of soil; also a device for collecting soil water in the field.

Micronutrient: A chemical element necessary for plant growth in amounts below 1 mg/L.

Mineralization: The conversion of an element from an organic form to an inorganic form as a result of microbial decomposition.

Overland flow: Wastewater treatment by spray-runoff (also known as "grass filtration") in which wastewater is sprayed onto gently sloping, relatively impermeable soil that has been planted to vegetation. Biological oxidation occurs as the wastewater flows over the ground and contacts the biota in the vegetative litter.

Pathogenic organisms: Microorganisms that can transmit diseases.

Percolation: The movement of water through the soil pores once it has passed the soil-water interface.

Phytotoxic: Toxic to plants.

Primary effluent: Wastewater that has been treated by screening and sedimentation.

Refractory organics: Organic materials not removed in secondary treatment.

Ridge-and-furrow method: The surface application of water to the land through formed furrows; wastewater flows down the furrows, and plants may be grown on the ridge.

Saline soil: A nonalkali soil containing sufficient soluble salts to impair its productivity.

Secondary treatment: Treatment of wastewater by physical, chemical, or biological means such as trickling filters, activated sludge, or chemical precipitation and filtration.

Sewage farming: Originally involved the transporting of sewage to rural areas for land disposal. Later practice includes reusing the water for irrigation and fertilization of crops.

Soil texture: The relative proportions of the various soil separates--sand, silt, and clay.

Soil water: That water present in the soil pores in an unsaturated zone above the groundwater table.

Spraying: Application of water to the land by means of stationary or moving sprinklers.

Spray-runoff: See overland flow.

Tilth: The physical condition of a soil as related to its ease of cultivation.

Transpiration: The net quantity of water absorbed through plant roots and transpired plus that used directly in building plant tissue.

Viruses: Submicroscopic biological structures containing all the genetic information necessary for their own reproduction but dependent for reproduction upon living cells.